



FALSE MEMORY, EMOTION, AND SELF

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Do emotional valence and arousal increase semantic false recognition, orthographical false recognition, and suggestibility? Does emotion of memory targets have different effects than emotion of retrieval contexts? How, at a process level, does emotion influence these false memories? I investigated those questions in college students using associative recognition tasks, in which emotional valence and arousal can be manipulated factorially over cue and target sides. The importance of distinguishing between emotional context and emotional content was confirmed because emotion effects varied from side to side. The importance of factorial manipulation of valence and arousal was also confirmed because they had distinct and interactive effects on true and false memories, and more fundamentally, on gist and verbatim processes.

I also investigated was positive bias in autobiographical memory. I studied the behavior of reconstructing over positive details of past performance as a function of gist interference and self goal regulation. Participants exhibited a general tendency to reconstruct in favor of themselves. This positive bias was especially strong when the performance was positively evaluated or when the performance was believed to facilitate goal achievement. Interestingly, gist and self goal were operative in different situations: Performance with low self-relevance was predominantly sensitive to gist manipulation, whereas performance with high self-relevance was exclusively responsive to self goal manipulation, resulting in either increased or decreased positive bias for the purpose of reducing the discrepancy between the goal and the current self.

BIOGRAPHICAL SKETCH

Yi Yang was born to Huiguang Yang and Dingding Ren in Wuhan, China, on October 16, 1981. She attended the No. 1 Middle School Affiliated to Central China Normal University in Wuhan, and received a B. A. in law and B. S. in psychology from Wuhan University and Central China Normal University, respectively. She graduated from University of Oxford, in Oxford, United Kingdom, in 2005 with a M. S. in psychology. In 2006, she joined the Memory and Neuroscience Laboratory in the Department of Human Development at Cornell University to pursue a doctoral degree in developmental psychology. She published on topics such as false memory, emotion, and autobiographic memory. She completed her Ph.D. in 2010, at which time she began post-doc respecialization in clinical psychology at University of Massachusetts at Amherst.

To my family and friends

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TABLE OF CONTENTS

Biographical Sketch	iii.
Dedication	iv.
Acknowledgements	v.
Lists of Figures	vii.
Lists of Tables	viii.
Chapter1	1
General Introduction	2
References	5
Chapter 2	7
Abstract	8
Introduction	9
Method	15
Results	22
Discussion	30
Reference	35
Chapter 3	40
Abstract	41
Introduction	42
Method	48
Results	53
Discussion	61
Footnotes	67
Reference	68
Chapter 4	74

Abstract	75
Introduction	76
Method	80
Results	84
Discussion	87
Reference	90
Chapter 5	95
Abstract	96
Introduction	97
Method	101
Results	104
Discussion	109
Reference	113
Chapter 6	119
General Discussion	120
Reference	123

LIST OF FIGURES

Figure 5.1. Over-report as a function of evaluative gist and self goal	108
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LIST OF TABLES

Table 2.1. Valence and arousal	19
Table 2.2. Proportions of “old” responses	24
Table 2.3. P_r values	25
Table 3.1. Valence and arousal	50
Table 3.2. Proportions of “old” responses	55
Table 3.3. P_r values	56
Table 4.1. Valence and arousal	82
Table 4.2. Suggestibility, confidence, and true memory	85
Table 5.1. Actual and retrieved responses	105

CHAPTER 1

General Introduction

Memory is crucial for building knowledge of the world and constructing a history of the self. Contrary to past metaphor of memory as a storehouse of original experience, memory is affected in powerful ways by external and internal factors at stages of encoding and recollection (Bartlett, 1932; Loftus, 1979, 1993, 1997; Koriat & Goldsmith, 1996; Schacter, 1996, 1999). As a consequence, it is highly malleable and often deviates from the real experience (for reviews, see Brainerd & Reyna, 2005). The prevalence of false memories is intriguing and has direct implications for fields that are central to human welfare, where memory accuracy is crucial, such as the law, medicine, and psychotherapy (for reviews, see Brainerd & Reyna, 2005).

A key feature of the past events (e.g., witnessing a robbery, experiencing the death of a parent) that may foment especially high levels of false memory is that the events are emotionally charged. Although studies on how false memory is influenced by the emotional qualities of experience have begun to accumulate (e.g., Anderson & Shimamura, 2005; Brainerd, Stein, Silveira, Rohenkohl, & Reyna, 2008; Budson, Todman, Chong, Adams, Kensinger, Krangel, & Wright, 2006; Howe, 2007), the findings are inconsistent. There are two possible explanations for the observed inconsistencies. The first is that valence and arousal have been confounded. For example, negative material is not only more negative but also more arousing than neutral material (e.g., Budson, Todman, Chong, Adams, Kensinger, Krangel, & Wright, 2006; Pesta, Murphy, & Sanders, 2001). Thus, it is impossible to say whether the observed differences between negative and neutral material on memory are valence effects or arousal effects or both.

The second is that emotion has been either manipulated as a content variable only or as a context variable only. As McGeoch (1942) maintained, "Everything learned is in response to stimulating or antecedent conditions which are a part of the learning situation and specific to it" (p. 501). It is traditional to distinguish between

two basic forms of information that are present in study materials: the *contextual cues* that accompany the presentation of target items and the *content* of the items themselves. A neutral target can be encoded with an emotional cue, and an emotional target can be encoded with an otherwise neutral cue. Therefore, it is important to progress to designs in which (a) emotion is manipulated over both context and content and (b) the context and content manipulations are comparable.

In addition to emotion, the self is another factor of interest that may contribute to memory distortions. As James Mill (1869) wrote, “The phenomenon of Self and that of Memory are merely two sides of the same fact, or two different modes of viewing the same fact. ... This succession of feelings, which I call my memory of the past, is that by which I distinguish my Self” (p. 174). Based on the interconnectedness of memory and the self, memory reconstruction is subject to the control of the self and often biased in favor of the self (Conway, 2005; Conway & Pleydell-Pearce, 2000). Note that memory distortions in general occur due to people’s reliance on meanings and patterns of the experience (gist) rather than the specific details (Brainerd & Reyna, 1998, 2005; Ceci & Bruck, 1998). Taken together, what are the effects of the self and gist interference on positive bias of autobiographical memory? This question remains unclear.

Recognizing the current issues on false memory and additional factors that may influence it, the present project attempts to address these issues and examine the effects of two additional factors, that is, emotion and the self. Four empirical studies are presented, each focusing on a certain subtype of false memory: semantic false memory (Chapter 2), orthographic false memory (Chapter 3), suggestibility (Chapter 4), and positive bias in autobiographical memory (Chapter 5). The following questions concerning false memory, emotion, and self are asked: (a) Do emotional valence and arousal increase semantic false recognition, orthographical false recognition, and

suggestibility? (b) Does emotion of memory targets have different effects than emotion of retrieval contexts? (c) How, at the gist and verbatim process level, does emotion influence these false memories? What are the effects of the self and gist processing on positive bias in autobiographical memory?

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CHAPTER 2

How Do Valence and Arousal Affect Semantic False Memory?

Abstract

This study was motivated by three questions: Does emotion increase semantic false recognition? Does emotion has the same effects on the cue and target sides? And how, at a process level, does emotion influence such errors? We manipulated valence and arousal factorially over retrieval contexts and memory targets using an associative recognition task. We obtained results that reconciled some inconsistencies between experiments in which emotion was manipulated either on the context side only or on the target side only. We found that negative valence increased false memory. The importance of distinguishing between emotional context and emotional content was confirmed because emotion's effects were different on the cue and target sides. At a process level, negative valence both suppressed verbatim and enhanced gist on the target side but only suppressed verbatim on the cue side; while high arousal suppressed verbatim on the target side but enhanced it on the cue side.

How Do Valence and Arousal Affect Semantic False Memory?

A Context-Content Framework

This research focused on three questions about semantic false memory of cue-target word pairs. One question was, does emotion increase or decrease error rates in semantic false recognition? Further, does emotion has the same effect on the cue and target sides? The last, more fundamental, question was how, at a process level, does emotion influence such recognition errors? That is, are processes that increase false-memory responses, processes that suppress them, or both affected? We provide some background on these questions before reporting our research.

BACKGROUND

Emotion

Laboratory findings have indicated that emotion and memory are interactive (see Storbeck & Clore, 2007; Bower, 1981; Dewey, 1894). To study how emotion affects memory, it is important, first, to specify dimensions of emotion. One of the most widely accepted conceptualizations of these dimensions was developed by Russell and colleagues. Russell and Mehrabian (1977) examined 42 commonly reported affects. They found that those affects were composed of three factors: valence, arousal, and dominance, with valence and arousal accounting for most of the variance (see also, Lang, Greenwald, Bradley, & Hamm, 1993; Russell, 1979; Russell, 1980; Russell, Weiss, & Mendelsohn, 1989). The valence dimension ranges from positive to neutral to negative, while the arousal dimension ranges from soothing/calming to exciting/agitating. According to the model, emotions with the same valence may have different levels of arousal. For instance, anger and sadness are both negative in valence, but anger is more arousing than sadness. Similarly, emotions with the same arousal level may have opposite valences. For example, anger and happiness are both highly arousing, but anger is negative and happiness is positive. Cognitive appraisals

provide even more detailed conceptualizations of emotions, which we have integrated with approaches based on valence and arousal, but the latter dimensions are the focus of the present research (see Rivers, Reyna, & Mills, 2008).

Emotional Memory

Emotional memory is regarded as a “domain of declarative memory, namely, memory for events or stimuli that are themselves emotional, or that occurred in an emotional context” (Buchanan & Adolphs, 2004; p. 43). In line with this, researchers have studied emotion’s effects from two perspectives. Some have embedded emotion in memory content by simply using emotional stimuli (e.g., words, pictures) as the to-be-tested targets, while others have manipulated emotion in memory context by embedding emotion in adjacent items that coexist with the neutral memory targets. Memory performance for targets is measured, and emotion’s effects are analyzed. An important fact about these methodologies is that they have yielded inconsistent findings, which we review below before discussing how they inspired our research.

Content Manipulation of Emotion: in Target Material

As the first approach to studying emotion’s effects on false memory, emotion of the to-be-remembered material is varied. Here, Budson, Todman, Chong, Adams, Kensinger, Krangel, and Wright (2006) developed an emotional analogy of the Deese-Roediger-McDermott (DRM) paradigm. A standard DRM paradigm (Deese, 1959, Roediger, Watson, McDermott, & Gallo, 2001) presents subjects with lists of semantic associates (e.g., *door, glass, pane, shade, ledge, sill*, etc.) that converge on a non-presented “theme word” or “critical lure” (e.g., *window*) and then tests their memory for the studied lists. Subjects frequently intrude the critical lures on free recall tests and exhibit very high levels of false alarms to these words on recognition tests. In Budson et al.’s (2006) emotional DRM paradigm, they generated lists on which the presented words (e.g., *sex, man, violate*, etc.) are semantically related to

negatively-valenced critical lures (e.g., *rape*) and lists on which the presented words (e.g., *door, glass, pane, etc.*) were semantically related to neutral critical lures (e.g., *window*). In a study of younger adults, older adults, and patients with Alzheimer's Dementia, negative and neutral lists were presented. False recognition of negative critical lures was elevated in younger and older adults, but signal detection analyses revealed that this was a response bias effect rather than a memory effect. Budson et al. concluded that negative lists do not elevate false memory but they create a liberal response bias in subjects.

By contrast, Howe (2007), using the same lists, found that negative lists did elevate false memory. He studied recall and recognition of Budson et al.'s (2006) lists with 8 and 12 year old children. His key results were that (a) for true recall, neutral items were better recalled than negative items, (b) for true recognition, neutral items also were better recognized than negative items, (c) for false recall, negative items were recalled less often than neutral ones, and (d) for false recognition, negative items were recognized more often than neutral ones. Signal detection analyses indicated that findings b and d were indeed memory effects. Howe's results are subject to two limitations. First, his recognition data were contaminated by prior recall: recall always preceded recognition. Second and more important, Budson et al. (2006) did not separate valence from arousal: The negative lists were more arousing than the neutral lists. Therefore, it is unclear whether Howe's results were due to valence, arousal, or both.

Brainerd, Stein, Silveira, Rohenkohl, and Reyna (2008) separated the effects of valence from arousal in some experiments with adults. They generated negative, neutral, and positive DRM lists that were equated on arousal. They found that false memory levels were highest for negative lists, intermediate for neutral lists, and lowest for positive lists. Application of a mathematical model (Brainerd, Wright,

Reyna, & Mojardin, 2001) to these data revealed that as one progresses from positive to neutral to negative valence, (a) the perceived meaning resemblance between false and true items increases, and (b) subjects' ability to use verbatim memories of true items to suppress errors decreases. However, it was not yet clear, from their study, the effects of arousal when disentangled with valence.

Contextual Manipulation of Emotion: in Adjacent Material

The other approach manipulates emotion in contextual material. One recent example of this approach was Touryan, Marian, and Shimamura's (2007) study. They presented participants with neutral objects in conjunction with negative or neutral pictures. In addition to memories for the objects and the pictures, they also measured object-in-picture memories with cued associative force-choice recognition tests. Although negative pictures were remembered better than neutral pictures, the object-in-picture memories were less accurate when objects were encoded in the context of negative pictures, compared with in neutral pictures. However, because negative pictures were not only more negative in valence but also higher in arousal than neutral pictures, it was not clear whether the decrease was due to valence or arousal or both.

Another study by Anderson and Shimamura (2005) was similar but with better control on arousal. Participants were asked to listen to neutral words while seeing silent films. The films fell into four categories: "negative" (negative valence and high arousal; a surgical arm amputation), "positive" (positive valence and medium arousal; playful penguins on glaciers), "arousing" (positive valence and high arousal; a car running through the city and country streets), and "control" (non-emotional; a person mixing batter). They found that word recognition was worse when the words were presented with the "negative" film clips, but better when the words were presented with the "arousing" film clips. That is, the negatively arousing

context impeded word recognition, while the positively arousing context enhanced it. However, low and medium levels of arousal were not included, so it is unknown how recognition will respond to valence when arousal is low or medium.

The Present Experiment

As we have seen, the influence of emotion on false memory has been studied by manipulating emotion as a context variable (Anderson & Shimamura, 2005; Marian, & Shimamura, 2007) or as a content variable (Brainerd et al., 2008; Budson et al., 2006; Howe, 2007). The studies that manipulated emotional content have not manipulated emotional context, and the others that manipulated emotional context have not manipulated emotional content (the content is predominantly neutral). In real life, however, it is hardly possible to segregate content from context because information is processed in association. Episodic memory consists of a rich array of interrelated components. Among them, the target item, for which memory is tested, is considered as *content*; while the other information, which is encoded with the target and later used to cue the retrieval of the target, is referred to *context*. Context is proposed by memory theorists to play a critical role in pointing at and limiting retrieval to a small, localized region of long-term memory by uniquely specifying an event in enough detail to distinguish it from other similar events stored in memory (Malmber & Shiffrin, 2005). Both context and content can be emotionally charged. For instance, a neutral target can be encoded with an emotional cue, and an emotional target can be encoded with an otherwise neutral cue. Memory is under their conjoint influence. Therefore, it is important to progress to designs in which (a) emotion is manipulated over both context and content and (b) the context and content manipulations are comparable. Thus, we propose a context-content framework that simultaneously considers emotion on both sides in a factorial way. By doing so, we are able to obtain a comprehensive picture of emotion's effects on memory, including

the overall effects of contextual valence, contextual arousal, content valence, and content arousal, as well as their interactions. This is the logic of our study.

We adopted an associative recognition task, which integrated the first two methods (content manipulation of emotion in target materials and contextual manipulation of emotion in adjacent materials). Specifically, emotion was manipulated on the cue and target sides of word pairs. In a standard associative recognition task, subjects study word pairs and are usually asked to respond to three types of pairs on a recognition test: (a) intact pairs, (b) rearranged pairs, and (c) lure pairs. For example, if subjects studied $A-B$ and $C-D$, but not $E-F$, then $A-B$ and $C-D$ are intact pairs, $A-D$ and $C-B$ are rearranged, and $E-F$ is a lure pair. Owing to the aims of our experiment, the three types of test pairs we were most interested in were intact pairs ($A-B$, $C-D$), semantic associate pairs ($A-B'$, $C-D'$) and unrelated pairs ($A-E$, $C-F$). We also presented rearranged pairs ($A-D$, $C-B$). The semantic associate pairs were ones in which the cue word had been studied, and the target word was the strongest forward associate of the studied target word. These associates were selected from the Nelson, McEvoy, and Schreiber (1998) norms. The unrelated pairs were ones in which the cue word had been studied but the target word was unrelated to the studied target word. We were interested in whether participants were able to reject a new target (a semantic associate of the old target or an unrelated distractor) with the presence of a cue with which the old target was encoded. Thus, in our design, the cue words of all test pairs had been studied, whereas target words were of these types: studied, unstudied but associated, unstudied and unrelated, and rearranged.

We used the associative recognition paradigm because it is a standard technique for factorial manipulations of variables (valence and arousal in this instance) over context and content (i.e., cues and targets). For each of the study pairs and the three types of test pairs, the factorial structure was 3 (cue valence: negative,

neutral, positive) \times 3 (cue arousal: low, medium, high) \times 3 (target valence: negative, neutral, positive) \times 3 (target arousal: low, medium, high). By adopting this design, the effects of negative and positive valence could be compared to a neutral baseline, and the effects of arousing and calming words could be compared to an intermediate baseline. Also, by manipulating valence and arousal over members of study and test pairs, this design allowed us to determine whether emotion's effects on the encoding/retrieval context (cue words) were the same as its effects on the content of to-be-tested items (target words), and whether they interacted.

Concerning the context manipulation, it is worth noting that the literature classified context into two types: independent and interactive. The interactive context refers to contextual variables that influence the processing of the target item, for example, co-presented items. By definition, interactive context implies that it may implicitly bias how the target item is processed. Therefore, if the emotion of the cue ever shadowed that of the target in a pair (e.g., *roach* — *table*), we aligned such effects with the general effects of context.

METHOD

Subjects

The subjects were 216 students at a university in the United States, who were native speakers of English (mean age=20 years, 72.2% female).

Materials

We used the affective norms for English words (ANEW; Bradley & Lang, 1999) for emotional manipulation. In the ANEW, each word is rated on 9-point scales for both valence and arousal in response to the Self-Assessment Manikin (Lang, 1980). The valence scale ranges from a smiling happy figure (positive valence; corresponding with the numeric value 9) to a frowning, unhappy figure (negative valence; numeric value 1); and the arousal scale ranges from an excited, wide-eyed

figure (high arousal; corresponding with the numeric value 9) to a relaxed, sleepy figure (low arousal; numeric value 1). The arousal scores for words were correlated with physiological measures of arousal in people, including changes in heart rate and skin conductance (Lang, Bradley, & Cuthbert, 1998). According to the normative scores in the ANEW, we sampled words at three levels of valence and arousal: negative valence (value < 3.07), neutral valence (4.13 < value < 5.76), positive valence (value > 7.06), low arousal (value < 4.10), medium arousal (4.84 < value < 5.54), and high arousal (value > 6.00). Thus, the word pool filled the nine cells of a 3 (valence) \times 3 (arousal) matrix. In each cell, we selected 108 words, which were randomly assigned to be cues or targets. The total 486 cues and 486 targets were randomly paired such that six fell into each of the 81 cells of a 3 (cue valence) \times 3 (cue arousal) \times 3 (target valence) \times 3 (target arousal) matrix. These word pairs were divided evenly into two sets, one for half of the participants. Due to the length, each set was divided into three sub-lists. Each sub-list included another eight pairs which would be tested as rearranged pairs later. In addition each sub-list began and ended with an additional five pairs as primacy and recency buffers, which came from unused items in the sample of words from the ANEW norms.

For the test list, the word pairs were randomly assigned to one of the three conditions: one third were old study pairs (intact pairs), one third preserved the cue word of a study pair but replaced the target word with its semantic associate (associate pairs), and the other one third preserved the cue word of a study pair but replaced the target word with an unrelated distractor (unrelated pair). For the associate pairs, we searched for the semantic associates in the Nelson et al. (1998)'s norms of association, then looked up the valence and arousal scores of these associates in the ANEW. Usually, a word and its strongest associate were consistent in valence and arousal. For example, for an associative pair *INFORMATION – PILLOW*, *sleep* was the strongest

associate of the target *pillow* in the Nelson et al.'s norms, and as positive and low-arousal as *pillow* in the ANEW (for *pillow*, valence = 7.92, arousal = 2.97; for *sleep*, valence = 7.2, arousal = 2.8). Thus, subjects were asked if *INFORMATION – SLEEP* was studied when they actually studied *INFORMATION – PILLOW*. In less frequent cases, the strongest associate was emotionally inconsistent with the target. For instance, *Christmas* in *ATHLETICS – CHRISTMAS* was replaced by its second strongest associate *holiday*, because the first strongest associate, *tree*, was distinct from *Christmas* in arousal (3.42 for *tree* vs. 6.27 for *Christmas*), whereas *holiday* (valence = 7.55, arousal = 6.59) was as positive and high-arousal as *Christmas* (valence = 7.80, arousal = 6.27). For the unrelated condition, the unrelated distractors came from unused items in the sample of words from the ANEW norms. Because the unrelated pairs were to be used as response bias controls in signal detection analyses, we controlled word length and word frequency, using Kucera and Francis's (1967) norms. The replacement of targets by unrelated distractors was done by random assignment except that we controlled emotional consistency between targets and unrelated distractors. The primacy and recency pairs on the study list did not figure in the test list.

The mean valence and arousal values of studied cues, studied targets, associate targets, and unrelated targets are reported in Table 2.1. There were two features of the emotional manipulation in our study. Firstly, the valence and arousal scores for each cell of the 3 (valence) \times 3 (arousal) matrix were equated among cues, targets, semantic associates, and unrelated distractors. Secondly, emotion varied on a manipulated dimension when not varying on the alternative dimension. That is, the numeric value of a certain level of a dimension remained equal across the three levels of the other dimension. For instance, the valence scores differed significantly among negative (valence) – high (arousal), neutral–high, and positive–high, but their arousal

scores did not differ statistically. This was valid for cues, targets, semantic associates, and unrelated distractors.

Table 2.1. Means and standard deviations of valence and arousal

Emotion	Cue		Target		Semantic Associate		Unrelated Distractor	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Negative Low								
Valence	3.07	.63	3.07	.63	3.04	1.04	3.04	.44
Arousal	4.10	.33	4.10	.33	4.10	.08	4.04	.58
Neutral Low								
Valence	5.14	.50	5.14	.50	5.81	.20	5.12	.28
Arousal	3.42	.38	3.42	.38	3.77	.13	3.64	.26
Positive Low								
Valence	7.07	.45	7.07	.45	7.06	.44	7.21	.41
Arousal	4.02	.57	4.02	.57	3.88	.64	3.88	.71
Negative Medium								
Valence	2.33	.38	2.33	.38	2.44	.69	2.37	.27
Arousal	5.27	.39	5.27	.39	4.90	.58	5.19	.43
Neutral Medium								
Valence	5.39	.71	5.39	.71	4.13	1.51	5.08	.79
Arousal	4.84	.29	4.84	.29	5.27	.83	4.84	.65
Positive Medium								
Valence	7.88	.51	7.88	.51	7.61	.46	7.40	.19
Arousal	5.35	.30	5.35	.30	5.47	.54	5.54	.30
Negative High								
Valence	2.16	.33	2.16	.33	2.59	.62	2.26	.46
Arousal	6.46	.54	6.46	.54	7.29	.54	6.70	.49

Table 2.1. (Continued)

Neutral High

Valence	5.76	1.15	5.76	1.15	5.17	2.07	5.60	1.48
Arousal	6.05	.38	6.05	.38	6.60	.50	6.00	.67

Positive High

Valence	7.93	.46	7.93	.46	8.04	.35	7.85	.48
Arousal	6.70	.63	6.70	.63	7.12	.47	6.69	.66

Procedure

Subjects participated in an associative recognition task in which they studied three sub-lists of word pairs and responded to three recognition tests, one for each sub-list. Half of the participants received one set of word pairs, and the other half received the other set. The order of presentation of sub-lists was random. On the recognition test, the cue word of each pair was always old (appeared in a studied pair), whereas the target could be either old (appeared with the cue word at study), or a semantic associate, or an unrelated distractor, or a rearranged distractor. For instance, if *dignified—tornado* was an original word pair on the study list, then *dignified—tornado* was old cue—old target, *dignified—hurricane* was old cue—semantic associate, and *dignified—addict* was old cue—unrelated distractor. The recognition instructions emphasized that subjects were to decide whether the word presented with the cue was identical to the one paired with that cue on the study list. During both the study and test phases, word pairs were presented on a front-projection screen, one pair at a time, with a presentation rate of 2.5 sec per pair.

RESULTS

Qualitative Patterns

The proportions of “old” responses to intact pairs, associate pairs and unrelated pairs as a function of context valence, context arousal, target valence, and target arousal appear in Table 2.2. Subjects exhibited about a 35% hit rate and about a 15% false-alarm rate for associate pairs (in which only one related target was studied). We corrected the raw “old” responses for response bias (for corrected values, see Table 2.3) with the familiar two-high threshold statistic *Pr* (see Snodgrass & Corwin, 1988). The design of our experiment did not permit other signal-detection statistics (such as *A'* and *d'*) to be used. That is because, for each subject, there was one test probe in each of the 243 cells of the 3(type: intact, associate vs. unrelated) \times 3 (cue

valence) \times 3 (cue arousal) \times 3 (target valence) \times 3 (target arousal) factorial structure. The computation of other statistics would require within-cell replications. It is important to note in this connection that prior false-memory experiments have found that P_r , A' , and d' produce similar findings and that P_r can be more sensitive to treatment effects than A' and d' (Seamon, Luo, Kopecky, Price, Rothschild, Fung, & Schwartz, 2002). An interpretive advantage of P_r is that its values, like raw hit and false-alarm rates, are probabilities. According to a series of analyses of variance (ANOVAs), (a) context valence (negative but not positive) decreased true memory but did not affect false memory, (b) context arousal (low and high) increased true but did not affect false memory, (c) content valence (negative and positive) decreased true memory and increased false memory, and (d) content arousal (high but not low) decreased true memory but did not affect false memory.

Table 2.2. Proportions of “old” responses to true targets, semantic associates, and unrelated distractors as functions of context valence, context arousal, target valence, and target arousal

		True		Semantic		Unrelated	
		Targets		Associates		Distractors	
		Mean	SD	Mean	SD	Mean	SD
Cue Valence	Negative	.33	.01	.14	.01	.10	.01
	Neutral	.37	.01	.15	.01	.11	.01
	Positive	.34	.01	.14	.01	.10	.01
Cue Arousal	Low	.36	.01	.14	.01	.11	.01
	Medium	.33	.01	.14	.01	.11	.01
	High	.35	.01	.14	.01	.10	.01
Target Valence	Negative	.33	.01	.16	.01	.10	.01
	Neutral	.36	.01	.12	.01	.10	.01
	Positive	.35	.01	.15	.01	.11	.01
Target Arousal	Low	.36	.01	.13	.01	.10	.01
	Medium	.36	.01	.14	.01	.10	.01
	High	.32	.01	.16	.01	.12	.01

Table 2.3. P_r values for hit rates, false-alarm rates, and verbatim memory as functions of context valence, context arousal, target valence, and target arousal

		Hit		False-alarm		Verbatim	
		Mean	SD	Mean	SD	Mean	SD
Cue valence	Negative	.23	.01	.04	.01	.19	.01
	Neutral	.26	.01	.04	.01	.22	.01
	Positive	.24	.01	.04	.01	.20	.01
Cue arousal	Low	.25	.01	.03	.01	.22	.01
	Medium	.22	.01	.04	.01	.19	.01
	High	.26	.01	.05	.01	.20	.01
Target valence	Negative	.23	.01	.06	.01	.17	.01
	Neutral	.26	.01	.02	.01	.24	.01
	Positive	.24	.01	.04	.01	.20	.01
Target arousal	Low	.27	.01	.04	.01	.23	.01
	Medium	.26	.01	.04	.01	.21	.01
	High	.20	.01	.04	.01	.16	.01

True Memory ANOVA

We conducted a 3 (cue valence: negative, neutral and positive) \times 3 (cue arousal: low, medium and high) \times 3 (target valence: negative, neutral and positive) \times 3 (target arousal: low, medium and high) ANOVA of P_r values for hits to intact pairs. A significant Cue Arousal \times Cue Valence \times Target Valence \times Target Arousal interaction was obtained, $F(16, 3408) = 15.91$, $MSE = .26$, $p < .001$. According to post-hoc analyses, first, valence's effects were different on the cue and target sides, as indicated by a Cue Valence \times Target Valence interaction, $F(4, 852) = 6.28$, $MSE = .27$, $p < .001$. Second, arousal's effects were also different on the cue and target sides, as indicated by a Cue Arousal \times Target Arousal interaction, $F(4, 852) = 11.85$, $MSE = .24$, $p < .001$. Third, valence and arousal interacted on the cue side, $F(4, 852) = 4.04$, $MSE = .27$, $p < .001$. Fourth, valence and arousal interacted on the target side as well, $F(4, 852) = 38.42$, $MSE = .25$, $p < .001$. Fifth, valence affected true memory on both the cue side, $F(2, 426) = 3.11$, $MSE = .33$, $p < .05$, and the target side, $F(2, 426) = 6.80$, $MSE = .25$, $p < .001$. Arousal's effects were also significant on both sides, $F(2, 426) = 7.64$, $MSE = .25$, $p < .01$, and $F(2, 426) = 33.52$, $MSE = .28$, $p < .001$. The more detailed findings were these:

The overall picture of how valence affected true memory was simple: Relative to neutral cue, negative cue (but not positive cue) decreased the hit rate, $F(1, 213) = 7.40$, $MSE = .02$, $p < .01$. Relative to neutral target, negative and positive target both decreased the hit rate, $F(1, 213) = 14.48$, $MSE = .02$, $p < .001$, and $F(1, 213) = 5.36$, $MSE = .02$, $p < .05$, respectively. The overall picture for arousal was more complex: On the cue side, there was a U-shaped relation between arousal and the hit rate, quadratic $F(1, 213) = 14.53$, $MSE = .26$, $p < .001$. Both low and high arousal increased the hit rate, relative to medium arousal, $F(1, 213) = 9.02$, $MSE = .02$, $p < .01$, and $F(1, 213) = 13.69$, $MSE = .02$, $p < .001$. On the target side, however, high arousal

decreased the hit rate, relative to both low and medium arousal, $F(1,213) = 61.12$, $MSE = .54$, $p < .001$, $F(1,213) = 34.62$, $MSE = .54$, $p < .001$.

False Memory ANOVA

A parallel 3 (context valence: negative, neutral and positive) \times 3 (context arousal: low, medium and high) \times 3 (target valence: negative, neutral and positive) \times 3 (target arousal: low, medium and high) ANOVA was computed for the P_r values for false-alarm rates for semantic associate pairs. There was a Cue Arousal \times Cue Valence \times Target Valence \times Target Arousal interaction, $F(16, 3424) = 9.35$, $MSE = .19$, $p < .001$. Post-hoc analyses revealed: First, valence's effects were different on the cue and target sides, as indicated by a Cue Valence \times Target Valence interaction, $F(4, 856) = 4.12$, $MSE = .20$, $p < .01$. Second, arousal's effects also were different on the cue and target sides, as indicated by a Cue Arousal \times Target Arousal interaction, $F(4, 856) = 6.78$, $MSE = .18$, $p < .001$. Third, valence and arousal interacted on the cue side, $F(4, 856) = 16.00$, $MSE = .20$, $p < .001$. Forth, valence and arousal interacted on the target side, $F(4, 856) = 13.60$, $MSE = .20$, $p < .001$. Fifth, disregarding the interactions, only target valence had significant effects on false-alarm rates, $F(2,428) = 12.51$, $MSE = .20$, $p < .001$. Negative target valence decreased the false-alarm rates, relative to neutral target valence, $F(1,214) = 22.05$, $MSE = .02$, $p < .001$; to a lesser degree, positive target valence decreased the false-alarm rates as well, compared with neutral target valence, $F(1,214) = 12.06$, $MSE = .01$, $p < .01$.

Verbatim Memory ANOVA

For purposes of theoretical interpretation of the memory effects of emotion, we further asked the question "how, at a process level, does emotion increase memory errors". Fuzzy-trace theory (e.g., Brainerd & Reyna, 2005) posits that recognition involves the retrieval of two types of traces: verbatim (episodic traces of targets' surface forms) and gist (episodic traces of concepts, meanings, and relations). For true

memory, verbatim and gist traces work in concert to support hits. For false memory, however, they have opposite effects, with verbatim traces supporting correct rejections (e.g., “No, I didn’t see *dignified—hurricane*. It was *dignified—tornado*.”) and gist traces supporting false alarms (e.g., “It was a *storm*-like word.”). Consequently, if only gist processes are enhanced, true and false memories change in an associative way (i.e., both increase). By contrast, if verbatim processes are impaired while gist processes are enhanced, true and false memories change in a dissociative pattern (i.e., true memory decreases but false memory increases).

To approach this question, it would be desirable to have a pure measure of one memory processes or the other. As Schacter and associates (e.g., Schacter, Israel, & Racine, 1999) and Seamon and associates (e.g., Seamon et al., 2002) have shown, a simple recognition design such as the present one yields a relatively pure verbatim memory measure. The logic of that measure runs as follow. The hit rate can be thought of as the probability that verbatim memory is successful, plus the probability that gist memory is successful, plus response bias. The semantic false-alarm rate, on the other hand, can be thought of as the probability that gist memory is successful, plus the response bias, minus the probability that verbatim memory is successful. Therefore, subtracting the semantic false-alarm rate from the hit rate yields a measure of the accuracy of verbatim memory for intact pairs. We did that, for the various list conditions of the experiment and obtained a new set of “verbatim” P_r values for intact pairs.

We computed a 3 (context valence: negative, neutral and positive) \times 3 (context arousal: low, medium and high) \times 3 (target valence: negative, neutral and positive) \times 3 (target arousal: low, medium and high) ANOVA of the “verbatim” P_r values. We report the results in the same sequence as previously. Again, there was a Cue Valence \times Cue Arousal \times Target Valence \times Target Arousal interaction, $F(16,$

3408)=10.84, $MSE = .29$, $p < .001$. Post-hoc analyses of this interaction produced the following five patterns with respect to emotion's effects on verbatim memory. First, valence's effects were different on the cue and target sides, $F(4, 852) = 7.44$, $MSE = .29$, $p < .001$. Second, arousal's effects were different on the cue and target sides, $F(4, 852) = 16.88$, $MSE = .29$, $p < .001$. Third, valence and arousal interacted on the cue side, $F(4, 852) = 5.05$, $MSE = .30$, $p < .01$. Forth, valence and arousal interacted on the target side, $F(4, 852) = 13.00$, $MSE = .31$, $p < .001$. Fifth, valence affected verbatim memory on both sides, $F(2, 426) = 3.73$, $MSE = .37$, $p < .05$, $F(2, 426) = 4.36$, $MSE = .30$, $p < .05$, and so did arousal, $F(2, 426) = 28.11$, $MSE = .31$, $p < .001$, $F(2, 426) = 26.66$, $MSE = .33$, $p < .001$. The more detailed findings were these:

Negative cue decreased verbatim memory, relative to neutral cue, $F(1,213) = 7.97$, $MSE = .03$, $p < .01$. Negative and positive target suppressed verbatim memory, relative to neutral target, $F(1,213) = 53.11$, $MSE = .02$, $p < .001$, $F(1,213) = 25.85$, $MSE = .02$, $p < .001$. Turning to arousal, high and low cue arousal strengthened verbatim memory, relative to intermediate level, $F(1,213) = 7.96$, $MSE = .02$, $p < .01$, $F(1,213) = 3.67$, $MSE = .02$, $p = .057$. High target arousal impaired verbatim memory, relative to intermediate level, $F(1,213) = 26.34$, $MSE = .02$, $p < .001$.

Recall that low and high levels of cue arousal increased false memory, compared with medium level. It was not because of impairment on verbatim presentations, because verbatim P_r values did not differ with cue arousal. Instead, it was because of enhancement and overreliance on gist presentations, which was evidenced by the associative increase in true- and false-memory. With respect to target valence, verbatim traces were suppressed significantly by negative valence, indicated by a lower verbatim P_r value for negative than for neutral valence. In addition, the dissociation between true- and false-memory (true memory decreased but false memory increased) evidenced that gist processes were boosted as well. Thus,

negative valence increased false memory via both impairment of verbatim presentations and overreliance on gist presentations.

DISCUSSION

We obtained results that reconciled some inconsistencies between experiments in which emotion has been manipulated only on the content side or only on the context side. On the *context* side, our results agreed with Anderson and Shimamura's (2005) that negative valence decreased true memory. On the *content* side, our results agreed with Howe's (2007) and Brainerd et al.'s (2008) findings that negative valence both fomented false memory and suppressed true memory, relative to positive and neutral valence. Consistent with conjoint-recognition data that Brainerd et al. reported, the ANOVA of our "verbatim" *Pr* measure showed that negatively-valenced targets produced the lowest overall levels of verbatim memory, although we did not find a protective effect for positive valence as Brainerd et al. did.

Our experiment produced three results of general significance. First, the context-content distinction proved to be empirically significant because emotion's effects were dissimilar on the context and content sides. Second, valence and arousal had different effects on memory. Third, emotion (valence and arousal; contextual vs. content) influenced memory via dissociated processes. These findings are discussed respectively below.

Context-Content Framework

This study aimed to draw attention to the need to conduct experiments in which the valence and arousal components of emotion are factorially manipulated over retrieval contexts and memory targets. In principle, these two sources of emotional experience might have different consequences for true or false memory, and hence, a complete understanding of emotion's effects requires separation of context and content influences. Based on our results, the context-content distinction is

important because emotion's effects were dissimilar on one side and the other. Concerning valence, valence had significant overall effects on the target side but not on the cue side. In addition, positive valence differed from neutral valence on the target side but not on the cue side; only negative valence's effects were consistent from side to side. Turning to arousal, there was a U-shaped relation between arousal level and both true and verbatim memory on the cue side, but a monotonic relation on the target side. Moreover, the direction of arousal's effects was reversed: high arousal increased both true and false memory on the cue side but decreased them on the target side. In addition, context- and content-emotion interacted with each another, which also demonstrated the significance of having an integrative framework and simultaneously manipulating emotion over both sides.

Valence

Concerning overall effects, target valence was the only factor that had consistent significant effects on false memory. Although both negative and positive valence produced increase in false memory relative to neutral valence, negative valence increased it to a much larger extent. Thus, we focus further discussion on negative target valence. In understanding this effect, three potential explanations can be culled from the prior literature on memory and emotion: strengthened gist processing, suppressed verbatim processing, and overconfidence. Concerning the first, it should be noted that valence is a part of the gist of information, as evidenced by elevated false-alarm rates to distractors that only share valence relative to completely unrelated distractors (Brainerd et al., 2008; Rivers et al., 2008). In line with this, Talmi and Moscovitch (2004) proposed that valenced materials are more semantically dense and interconnected than neutral materials. Consequently, they proposed, the depth and richness of semantic processing are greater with valenced materials (e.g., Dewhurst & Parry, 2000; Ochsner, 2000). In that connection, such materials are known

to activate semantic operations such as evaluation and self-referential processing (e.g., Christianson, Loftus, Hoffman, & Loftus, 1991; Ochsner, 2000). Semantic processing has often been found to elevate false memory more than true memory, resulting in reductions in net accuracy (e.g., Payne, Elie, Blackwell, & Neuschatz, 1996; Toglia, Neuschatz, & Goodwin, 1999).

Second, as indicated by the verbatim *Pr* results, negative valence produced weaker verbatim traces than neutral valence. Using the conjoint-recognition model to measure the process-level effects of valence, Brainerd et al. (2008) found that variations in valenced content produced large differences in the model's verbatim- and gist-processing parameters. Consistent with what we found, the perceived gist resemblance between false and true items was strongest for negative content; meanwhile, subjects' ability to use verbatim memory to suppress errors was weakest for negative content. There is also evidence from neuro-imaging research for verbatim and gist effects of valence. For instance, Maratos, Allen, and Rugg (2000) measured event-related potentials (ERPs) of neural activity elicited by negative and neutral words during the performance of a recognition memory task. The behavioral data indicated that the false alarm rate for negative words was approximately doubled than that for the neutral words. What's more, the ERPs associated with recognizing negative and neutral words were different. For the neutral words, there was an early, bilateral, frontal effect which has been associated with familiarity-based recognition, a subsequent left parietal effect that has been associated with recollection, and an even slower right frontal effect that has been associated with post-retrieval monitoring. For the emotional words, however, the left parietal effect was of smaller magnitude and of shorter duration, and the right frontal effect was not evident at all. These differences indicate that veridical retrieval was activated to a lesser extent for the negative words, and familiarity-based processing dominated for such negative words.

Last, it has been shown in other lines of research that valenced materials increase people's confidence in the accuracy of remembered information (Christianson et al., 1991; Loftus, Loftus, & Messo, 1987; Sharot, Delgado, & Phelps, 2004). This boost in confidence occurs regardless of the objective accuracy of memory (e.g., Kensinger & Schacter, 2006; Levine & Bluck, 2004). Thus, confidence elevation may make people less likely to question the authenticity of false memories that arise from valenced material.

It is worth noting that our findings on negative valence are also consistent with other research using the DRM paradigm. For instance, Sharkawy, Groth, Vetter, Beraldi, and Fast (2008) presented participants with neutral and negative lists of words semantically associated to a non-presented critical lure, and then administered a recognition test. Critical lures associated with negative word lists elicited significantly more false memory than critical lures associated with neutral word lists. Therefore, our findings extend other results of negative valence's distortive effects in the DRM paradigm, as well as the associative recognition paradigm.

Arousal

It is well documented that high arousal facilitates long-term memory (e.g., Cahill & McGaugh, 1995; Kleinsmith & Kaplan, 1963, 1964; Walker & Tarte, 1963). However, in the case of more immediate memory tasks, findings have been inconsistent. Some studies have found a detrimental effect for intervals of about 30 minutes following original encoding (e.g., Butter, 1970; Kleinsmith & Kaplan, 1963, 1964; Walker & Tarte, 1963). Others, however, have found that high arousal leads to superior memory across this same interval (e.g., Corteen, 1969; Maltzman, Kantor, & Langdon, 1966). Interestingly, our study, which tested immediate recognition, found opposite effects of arousal on the cue and target sides: high arousal on the cue side increased hit rates, whereas high arousal on the target side decreased hit rates.

Noteworthy here is that, on the process level, high arousal boosted verbatim memory on the cue side but decreased verbatim memory on the target side.

Dual Processes

According to the fuzzy-trace theory, when *only* gist processes are enhanced or impaired, true and false memories respond similarly (i.e., both increase or decrease); when *only* verbatim processes are enhanced or impaired, true memory increases or decreases without changes in false memory; and when verbatim processes are impaired *and* gist processes are enhanced, true memory decreases but false memory increases. In connection with the verbatim *Pr* results, we found context and content emotion influenced memory via different processes. With respect to cue valence, negative valence decreased hits without significant changes in false-alarms, relative to neutral valence. These effects were primarily verbatim interference (supported by the verbatim *Pr* measures), something targets that are especially sensitive to. The same pattern was observed for cue arousal and target arousal. However, target valence displayed a different pattern. It both suppressed verbatim memory and boosted gist memory, resulting in increased false alarms as well as decreased hits. Thus, this study illustrates how results for hit rates, false-alarm rates, and verbatim *P_r* values can be integrated and pinpoints the likely process-level effects of valence and arousal.

People experience events in context. So the emotional qualities of context, as well as events themselves, are important. The current study is the first one we know of that factorially manipulated two dimensions of emotional experience, valence and arousal, over context and content. As demonstrated by our study, the two dimensions have different effects, and those effects vary as function of context versus content. These findings have potential implications for a wide variety of everyday memory situations whose hallmark is that the context or the content of to-be-remember

information is emotionally changed.

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CHAPTER 3

How Do Valence and Arousal Affect Orthographical False Memory?

Abstract

This study explored the effects of emotion on false memory for orthographically similar items. We separated the effects of emotion on memory context versus memory content via an associative recognition procedure: Three levels of emotional valence (positive, neutral, negative) and three levels of emotional arousal (high, medium, low) were factorially manipulated over the cue (context) and target (content) components of word pairs. In general, negative valence was more active than neutral or positive valence, and high arousal was more active than medium or low arousal in affecting true and false memory. However, their effects varied from side to side. Negative valence increased orthographic false memory consistently on the cue side but not on the target side; high arousal increased orthographic false memory on the cue side but decreased it on the target side. Negative valence decreased true memory on both cue and target sides; high arousal increased true memory on cue side but decreased it on target side. At a process level, negative valence consistently impaired verbatim process on both sides, while high arousal enhanced gist process on the cue side but impaired gist and verbatim processes on the target side.

How Do Valence and Arousal Affect Orthographic False Memory?

This study investigated three specific questions about how emotion affects orthographic false memory: (a) Does false recognition of words that are orthographically similar to studied items vary as a function of words' emotional attributes? (b) What are the respective effects of the valence and arousal components of emotion? And (c) Do valence and arousal have different effects when they are manipulated as part of contextual cues versus when they are manipulated as part of the to-be-tested items?

BACKGROUND

False memory consists of recalling or recognizing events that did not occur or misremembering portions of events that did occur. Further, to distinguish false memory from errors that arise from response bias, the events that are misremembered preserve salient semantic or perceptual features of actual events (e.g., the word *collie* when the word *poodle* was studied, or the word *cattle* when the word *battle* was studied) (e.g., Anisfeld & Knapp, 1968; Underwood, 1965; Wallace, Stewart, & Malone, 1995; Wallace, Stewart, Shaffer, & Barry, 1998). Since the mid-1990s, a large literature on false memory has accumulated, the great preponderance of which has focused on word-list tasks, such as the well-known Deese/Roediger/McDermott (DRM; Deese, 1959; Roediger & McDermott, 1995). The effects of a large number of theoretically-motivated manipulations have been studied, and as a result, false memory has been brought under rigorous experimental control (for a literature review, see Brainerd & Reyna, 2005).

Although the effects of many informative manipulations have been studied, a surprising omission, until recently, concerns how false memory is affected by words' emotional attributes. This is a surprising lacuna in the data base because the acceleration of false memory research in the 1990s was stimulated by the recognition

that such errors can be pervasive in some real-world situations that are fraught with emotion, such as police interrogations, eyewitness identifications of criminal suspects, and psychotherapy (for reviews, see Brainerd & Reyna, 2005; Ceci & Bruck, 1995). Recently, studies of how false memory is influenced by the emotional qualities of experience have begun to accumulate (e.g., Anderson & Shimamura, 2005; Brainerd, Stein, Silveira, Rohenkohl, & Reyna, 2008; Budson, Todman, Chong, Adams, Kensinger, Krangel, & Wright, 2006; Howe, 2007). The bulk of these studies have dealt with how emotion affects *semantic* false memory, and key finding has been that false memory for meaning-preserving words is elevated by words whose emotional valence is negative. At a process level, the reason seems to be that negatively-valence words generate strong gist memories of words' semantic content (see Brainerd et al., 2008). However, the literature remains very thin with respect to the question of how emotion affects the other fundamental type of false memory: the tendency to falsely remember items that preserve the physical rather than the semantic features of target materials. Consequently, we focus on that question in this research.

Although there is a modest amount of research with phonological DRM paradigm (e.g., Ballou & Sommers, 2008), emotion was not introduced in the procedure. The earliest relevant study was emotion in orthographic DRM paradigm conducted by Pesta, Murphy, and Sanders (2001). They asked whether emotional unstudied words that shared orthographic characteristics with neutral studied words would be less frequently recognized than neutral unstudied words that shared orthographic characteristics with neutral studied items. In other words, their hypothesis was that false memory effect for orthographically similar distractors would be suppressed if the distractors were emotional. In an initial experiment, they presented subjects with 12 lists of neutral words. The words on each list were orthographically related to an unstudied distractor. Half of the distractors were

negative (e.g., *penis*), and half were neutral (e.g., *digit*). Levels of false recognition were lower for the former than for the latter, which suggested that the effects of emotional valence on orthographic false memory were the opposite of its effects on semantic false memory (since negative valence was found to increase semantic false memory). Signal detection analyses revealed that false memory sensitivity was stronger for the neutral than the emotional distractors and that response bias was more liberal for the neutral than the emotional distractors. Pesta et al. argued that these were distinctiveness effects (e.g., see Schacter, Israel, and Racine, 1999): Negative distractors such as *penis* or *bitch* were so distinctive that subjects assumed that if they had studied such words, they would have clearly remembered it. Pesta et al. tested this conjecture in a second experiment by simply including three such words on the study lists (*fuck*, *piss*, and *asshole*). Consistent with their hypothesis, the false alarm rate for emotional distractors were more than doubled. Furthermore, signal detection analyses showed that false memory sensitivity was now equal for emotional and neutral distractors. Pesta et al. concluded that as long as emotional distractors were not highly distinctive, negative valence did not suppress orthographic false memory, relative to neutral valence.

Kensinger and Corkin (2004) extended Pesta et al.'s (2001) first experiment to older versus young adults. Both age groups falsely recognized more neutral than emotional distractors. The same pattern was observed with recall tests. Most recently, analogous findings were obtained in Chinese subjects with Chinese words. Huang and Yeh (2006) generated 24 lists of Chinese words, each of which consisted of 10 two-character Chinese words. On each list, 5 of the words shared the same *first* character with a distractor word, the other 5 shared the *second* character with that distractor, and all 10 were semantically unrelated to the distractor. In an initial experiment, the subjects studied 12 lists of neutral words, 6 that were orthographically

related to neutral distractors, 3 that were orthographically related to negative distractors, and 3 that were orthographically related to positive distractors. False alarm rates were higher for both positive and negative distractors than for neutral distractors. The results for negative distractors agreed with Pesta et al.'s and Kensinger and Corkin's findings, and the combined results for positive and negative distractors were consistent with the hypothesis that emotional distractors were so distinctive that they suppressed the orthographic false memory effect.

However, Kensinger and Corkin (2004) raised an important criticism of this hypothesis: It is unclear whether it is emotional distinctiveness that is operating or simply a broader form of distinctiveness that they called conceptual distinctiveness (i.e., the emotional contrast between targets and distractors). Huang and Yeh's (2006) reported a second experiment (Experiment 2C) that supported Kensinger and Corkin's criticism. It was similar with the aforementioned second experiment of Pesta et al.'s, but it lessened emotional contrast further. Specifically, they repeated their first experiment, except that the study lists included positive and negative words, both with lures of congruent valence. Now, when subjects could no longer rely on metacognitive awareness of a salient conceptual contrast between study and test lists, the effects of emotion on orthographic false memory flip-flopped: False-alarm rates were higher for positive and negative distractors than for neutral ones. Note that this effect is in line with the aforementioned findings about how emotion affects semantic false memory.

Summing up, it appears that orthographic false memory is not suppressed when distractors are emotional—as long as some emotional content is present in study lists, so that metacognitive distinctiveness is not confounded with emotion (Pesta et al., 2001). There is also some evidence (Huang and Yeh, 2006) that negative emotion has the same elevating effect on orthographic false memory as it is known to have on semantic false memory (e.g., Howe, 2007). Beyond this, however, there are two major

uncertainties that need to be resolved: (a) valence versus arousal confounds and (b) failure to separate contextual versus content influences of emotion.

Concerning a, the most obvious uncertainty concerns the respective effects of the two basic dimensions of emotion (see Lang, Greenwald, Bradley, & Hamm, 1993; Russell & Mehrabian, 1977): conceptual *valence* (negative, neutral and positive) and physical *arousal* (low, medium and high). In the larger literature on emotion, it is well established that valence and arousal have different effects, at both the behavioral and neurological levels. For instance, Kensinger (2004) documented several behavioral and neurological differences in the memory effects of valence and arousal.

However, in all of the experiments that were just summarized, valence and arousal were confounded. Specifically, negative and neutral distractors always differed in two ways—valence (e.g., *bitch* is conceptually more negative than *digit*) and arousal (e.g., *bitch* is physically more arousing than *digit*). Thus, it is impossible to say whether the observed differences between negative and neutral distractors on orthographic false memory were valence effects or arousal effects or both. In the literature on semantic false memory, however, valence and arousal have been separated, and available data show that semantic false memory is elevated by both negative valence and high arousal and that the valence effect is substantially larger than the arousal effect (see Brainerd et al., 2008).

Turning to the other uncertainty that is posed by extant studies of emotion effects in orthographic false memories, it is traditional to distinguish between memory for two basic forms of information that are present in study materials: the *contextual cues* that accompany the presentation of target items and the *content* of the items themselves. As with valence versus arousal, it is well known that variables can have different behavioral and neurological effects when they are manipulated over the context and target sides of memory experiments (e.g., see Malmberg, 2008). The

contextual and content sides of the effects of emotion were not separated in any of the aforementioned experiments. Indeed, like the valence and arousal components, context and content were confounded because item-recognition designs were used. In such designs, study list consisted of single target words, and tests lists consisted of single target and distractor words, and thus, the context and content were confounded because individual words provide both the memory content that was supposed to be accessed and the contextual cues that were used to access it. A traditional method of separating the contextual and content effects of variables is to switch to associative recognition tests, which allows variables to be factorially manipulate over the cue and target members of word pairs (for review, see Yonelinas, 2002).

In this study, we removed both of these limitations of prior research on how emotion affects orthographic false memory by imposing two design modifications. First, to eliminate the valence-arousal confound, I factorially manipulated three levels of valence (negative, neutral, positive) and three levels of arousal (high, medium, low) over study and test lists. Therefore, it was possible to measure the separate contributions of valence and arousal to false memory (and also to true memory). An additional advantage of this manipulation is that it was possible to compare the effects of both negative and positive valence to a neutral base line. In the studies that were discussed above, with the exception of a single experiment reported by Huang and Yeh (2006), it was not possible to determine the effects of both types of valence relative to a neutral baseline.

Second, to eliminate the context-content confound, we implemented an associative recognition design. That is, the subjects first studied a list of word pairs, and they were told that they would later take a memory test on which they would have to remember the target word that went with each cue word. Next, the subjects responded to a test list that also consisted of word pairs. On the test list, the cue

member of each pair had appeared on the study list as the cue member of one of the studied pairs. However, the target member of each test pair was either (a) the same target word that had appeared with that cue on the study list or (b) a new word (distractor) that had not appeared on the study list as either a cue or a target. With this basic design, it was able to separate the context and context effects of emotion by manipulating both valence and arousal factorially over the cue and target members of study pairs and test pairs.

METHOD

Subjects

216 native English speaking college students (mean age=20 years, 72.2% female) at a United States university participated in the study.

Materials

We used the affective norms for English words (ANEW; Bradley & Lang, 1999) to generate a large pool of words with which valence and arousal could be factorially manipulated over study and test lists. In the ANEW, each word is rated on 9-point scales for both valence and arousal. We sampled words at three levels of valence and arousal: negative valence (value < 3.14), neutral valence (4.96 < value < 5.60), positive valence (value > 7.03), low arousal (value < 4.14), medium arousal (4.88 < value < 5.54), and high arousal (value > 6.00). The resulting words filled the 9 cells of a 3 (valence) \times 3 (arousal) matrix. These words were randomly sampled to provide the cues and targets for the experiment. We generated two sets of word pairs. Each set contained 243 word pairs that provided 3 pairs for each of 81 cells in the 3 (cue valence) \times 3 (cue arousal) \times 3 (target valence) \times 3 (target arousal) list design. Half participants were presented with one or the other set. Due to the length, each set was presented as 3 sublists, with subject studying and being tested on each sublist before proceeding to the next sublist. Additional word pairs were added to be tested as

rearranged pairs later, and as primacy and recency buffers.

For each set, the word pairs were randomly assigned to one of the three conditions in test: old cue/old target (intact pairs), old cue/unpresented but orthographically similar target (associate pairs), and old cue/unpresented and unrelated target (unrelated pairs). The unrelated words were selected from the unused words in the ANEW. The associates were orthographic neighbors obtained from Nusbaum, Pisoni, & Davis's (1984) computational database of 20,000 English words. The primacy and recency pairs from the study list did not figure in the test list.

The mean valence and arousal values of studied cues, studied targets, associate targets, and unrelated targets are reported in Table 3.1. The valence and arousal scores for each cell of the 3 (valence) \times 3 (arousal) matrix were equated among cues, targets, orthographic associates, and unrelated distractors. Note that the mean of valence is equal across levels of arousal, and the mean level of arousal is equal across levels of valence. This is true for cues, targets, and unrelated distractors.

Table 3.1. Means and standard deviations of valence and arousal

Emotion	Cue		Target		Unrelated Distractor	
	Mean	SD	Mean	SD	Mean	SD
Negative Low						
Valence	3.14	.65	3.22	.64	3.04	.44
Arousal	4.14	.40	4.03	.45	4.04	.58
Neutral Low						
Valence	5.19	.48	5.42	.45	5.12	.28
Arousal	3.46	.41	3.42	.35	3.64	.26
Positive Low						
Valence	7.03	.48	7.11	.43	7.21	.41
Arousal	4.02	.56	4.07	.34	3.88	.71
Negative Medium						
Valence	2.39	.35	2.53	.44	2.37	.27
Arousal	5.29	.36	5.01	.24	5.19	.43
Neutral Medium						
Valence	5.11	1.06	5.50	.75	5.08	.79
Arousal	4.88	.24	5.03	.54	4.84	.65
Positive Medium						
Valence	7.89	.51	7.60	.36	7.40	.19
Arousal	5.38	.29	5.25	.34	5.54	.30
Negative High						
Valence	2.14	.34	2.12	.48	2.26	.46
Arousal	6.33	.44	6.33	.51	6.70	.49

Table 3.1 (Continued)

Neutral High

Valence	5.58	1.30	4.96	1.16	5.60	1.48
Arousal	6.15	.44	6.16	.46	6.00	.67

Positive High

Valence	7.83	.42	8.00	.38	7.85	.48
Arousal	6.76	.60	6.76	.52	6.69	.66

Procedure

We used a revised associative recognition task, which is a standard technique for factorial manipulations of variables (valence and arousal in this instance) over context and content. In such tasks, subjects study word pairs and are usually asked to respond to three types of word pairs on a recognition test: (a) intact pairs, (b) rearranged pairs, and (c) distractor pairs. For example, if subjects studied $A-B$ and $C-D$, but not $E-F$, then $A-B$ and $C-D$ are intact pairs, $A-D$ and $C-B$ are rearranged pairs, and (c) $E-F$ is a lure pair. Owing to the aims of this experiment, we revised the task to include four types of test pairs: intact pairs ($A-B$, $C-D$), associate pairs ($A-B'$, $C-D'$; in which B' and D' are orthographic associates of B and D , respectively), unrelated pairs ($A-E$, $C-F$; in which E and F are unrepresented and unrelated to B and D), and rearranged pairs ($A-D$, $C-B$).

The subjects studied three sublists of word pairs and responded to three recognition tests, one for each sublist. On each recognition test, the cue word of each pair was always old (appeared in a studied pair), whereas the target could be either old (appeared with that cue word at study), an orthographic associate of the previous target, a word that was unrelated to the previous target, or a re-arranged cue-target pair. The subjects were instructed to decide whether or not the target word went with each cue word in a studied pair. During both the study and test phases, word pairs were presented visually, in random order, on a front-projection screen, one pair at a time, with a presentation rate of 2.5 sec per pair.

RESULTS

Qualitative Patterns

According to the proportions of “old” responses to intact pairs, associate pairs and unrelated pairs as a function of context valence, context arousal, target valence, and target arousal (see Table 3.2), subjects exhibited about a 35% hit rate and about a

13% false-alarm rate for associate pairs (in which only one related target was studied). We then corrected the raw hit and false-alarm rates for associate pairs for response bias (for corrected values, see Table 3.3), using two-high threshold statistic Pr (see Snodgrass & Corwin, 1988). We chose Pr over other signal-detection statistics (such as A' and d') for two reasons. First, for each individual subject, the test list contained only one probe in each experimental condition. The computation of Pr does not require within-cell replication. Second, previous false memory experiments have found that Pr produces similar results to A' and d' , and that it is more sensitive to some treatment effects (Seamon, Luo, Kopecky, Price, Rothschild, Fung, & Schwartz, 2002).

Table 3.2. Proportions of “old” responses to true targets, orthographic associates, and unrelated distractors as functions of context valence, context arousal, target valence, and target arousal

		True Targets		Orthographic Associates		Unrelated Distractors	
		Mean	SD	Mean	SD	Mean	SD
Cue Valence	Negative	.33	.01	.14	.01	.10	.01
	Neutral	.37	.01	.13	.01	.11	.01
	Positive	.34	.01	.11	.01	.10	.01
Cue Arousal	Low	.36	.01	.13	.01	.11	.01
	Medium	.33	.01	.11	.01	.11	.01
	High	.35	.01	.13	.01	.10	.01
Target Valence	Negative	.33	.01	.13	.01	.10	.01
	Neutral	.36	.01	.12	.01	.10	.01
	Positive	.35	.01	.13	.01	.11	.01
Target Arousal	Low	.36	.01	.12	.01	.10	.01
	Medium	.36	.01	.13	.01	.10	.01
	High	.32	.01	.13	.01	.12	.01

Table 3.3. P_r values for hit rates, false-alarm rates, and verbatim memory as functions of context valence, context arousal, target valence, and target arousal

		Hit		False-alarm		Verbatim	
		Mean	SD	Mean	SD	Mean	SD
Cue valence	Negative	.23	.01	.04	.01	.20	.01
	Neutral	.26	.01	.02	.01	.24	.01
	Positive	.24	.01	.01	.01	.23	.01
Cue arousal	Low	.25	.01	.02	.01	.23	.01
	Medium	.22	.01	.004	.01	.22	.01
	High	.26	.01	.04	.01	.22	.01
Target valence	Negative	.23	.01	.03	.01	.20	.01
	Neutral	.26	.01	.02	.01	.25	.01
	Positive	.24	.01	.02	.01	.23	.01
Target arousal	Low	.27	.01	.03	.01	.25	.01
	Medium	.26	.01	.03	.01	.23	.01
	High	.20	.01	.003	.01	.19	.01

Using the bias corrected hit rate and the bias corrected false alarm rate for associate pairs, I conducted a series of analyses of variance (ANOVAs). The overall effects of context and content emotion on true and false memories were: (a) Context valence (negative but not positive) decreased true memory and increased orthographic false memory, relative to neutral valence; (b) content valence (negative and positive) decreased true memory but did not affect false memory, relative to neutral valence; (c) context arousal (low and high) increased both true and false memory, relative to intermediate level; and (d) content arousal (high but not low) decreased both true and false memory, relative to intermediate level.

True Memory ANOVA

A 3 (cue valence: negative, neutral and positive) $\times 3$ (cue arousal: low, medium and high) $\times 3$ (target valence: negative, neutral and positive) $\times 3$ (target arousal: low, medium and high) ANOVA of P_r values was computed for hits to intact pairs. The key result was a Cue Arousal \times Cue Valence \times Target Valence \times Target Arousal interaction, $F(16, 3408) = 15.91$, $MSE = .26$, $p < .001$. Post-hoc analyses of this interaction revealed that (a) emotional valence's effects were different than the effects of arousal, (b) the effects of arousal interacted with emotional valence's effects, and (c) the context effects of valence and arousal were different than the content effects. First, valence's effects were different on the cue and target sides, as indicated by a Cue Valence \times Target Valence interaction, $F(4, 852) = 6.28$, $MSE = .27$, $p < .001$. Second, arousal's effects were also different on the cue and target sides, as indicated by a Cue Arousal \times Target Arousal interaction, $F(4, 852) = 11.85$, $MSE = .24$, $p < .001$. Third, valence and arousal interacted on the cue side (i.e., the relation between context valence and the hit rate was different for different arousal levels), $F(4, 852) = 4.04$, $MSE = .27$, $p < .001$. Fourth, valence and arousal interacted on the target side (i.e., the relation between content valence and the hit rate was different for different

arousal levels), $F(4, 852) = 38.42$, $MSE = .25$, $p < .001$. Fifth, valence affected true memory on both the cue side, $F(2,426) = 3.11$, $MSE = .33$, $p < .05$, and the target side, $F(2,426) = 6.80$, $MSE = .25$, $p < .001$. So did arousal, $F(2,426) = 7.64$, $MSE = .25$, $p < .01$, and $F(2,426) = 33.52$, $MSE = .28$, $p < .001$, respectively. The more detailed findings were these:

Relative to neutral context, negative context decreased the hit rate, $F(1,213) = 7.40$, $MSE = .02$, $p < .01$, whereas positive context made no changes. Relative to neutral content, negative and positive content both decreased the hit rate, $F(1,213) = 14.48$, $MSE = .02$, $p < .001$, $F(1,213) = 5.36$, $MSE = .02$, $p < .05$, respectively. Turning to arousal, on the cue side, there was a U-shaped relation between arousal and the hit rate, quadratic $F(1,213) = 14.53$, $MSE = .26$, $p < .001$. Both low and high arousal increased the hit rate, relative to medium arousal, $F(1,213) = 9.02$, $MSE = .02$, $p < .01$, and $F(1,213) = 13.69$, $MSE = .02$, $p < .001$. On the target side, high arousal decreased the hit rate, relative to both low and medium arousal, $F(1,213) = 61.12$, $MSE = .54$, $p < .001$, $F(1,213) = 34.62$, $MSE = .54$, $p < .001$.

False Memory ANOVA

A parallel 3 (context valence: negative, neutral and positive) $\times 3$ (context arousal: low, medium and high) $\times 3$ (target valence: negative, neutral and positive) $\times 3$ (target arousal: low, medium and high) ANOVA was conducted for the P_r values for false-alarm rates for orthographic associate pairs. There was a Cue Arousal \times Cue Valence \times Target Valence \times Target Arousal interaction, $F(16, 3376) = 9.16$, $MSE = .17$, $p < .001$. According to post-hoc analyses, first, valence's effects were different on the cue and target sides, as indicated by a Cue Valence \times Target Valence interaction, $F(4, 844) = 13.58$, $MSE = .19$, $p < .001$. Second, arousal's effects also were different on the cue and target sides, as indicated by a Cue Arousal \times Target Arousal interaction, $F(4, 844) = 6.62$, $MSE = .17$, $p < .001$. Third, valence and arousal interacted on the

cue side, $F(4, 844) = 2.64$, $\eta^2 MSE = .17$, $p < .05$. Forth, valence and arousal interacted on the target side, $F(4, 844) = 7.74$, $\eta^2 MSE = .18$, $p < .001$. Fifth, valence's effects were restricted to the cue side, $F(2,422) = 6.28$, $MSE = .20$, $p < .001$. Negative context increased the false-alarm rate, relative to neutral or positive context, $F(1,211) = 5.55$, $MSE = .43$, $p < .05$, and $F(1,211) = 12.26$, $MSE = .38$, $p < .001$, respectively. Arousal, however, affected false memory on both sides, $F(2,422) = 8.55$, $MSE = .18$, $p < .001$, and $F(2,422) = 7.00$, $MSE = .20$, $p < .01$. There was a U-shaped relation between context arousal and the false-alarm rate, quadratic $F(1,211) = 5.00$, $MSE = .02$, $p < .001$. Low and high arousal increased it, relative to medium arousal, $F(1,211) = 5.47$, $MSE = .01$, $p < .05$, $F(1,211) = 18.07$, $MSE = .01$, $p < .001$. On the content side, high arousal decreased false memory, relative to low and medium arousal, $F(1,211) = 7.10$, $MSE = .44$, $p < .01$, $F(1,211) = 13.20$, $MSE = .38$, $p < .001$.

Verbatim Memory ANOVA

In order to aid theoretical interpretation of emotion's effects on memory, we report a further ANOVA that was more process oriented. According to fuzzy-trace theory (e.g., Brainerd & Reyna, 2005), there are two types of representations of study list words that underlie true and false recognition: verbatim traces of their surface forms and gist traces of relational information. Verbatim traces are episodically tagged representations of words' surface features, whereas gist traces are episodically tagged representations of their meanings, senses, and patterns (e.g., Brainerd & Reyna, 2005; Reyna & Brainerd, 1995). The two types of representations work in concert to support true memory, but they have opposite effects on false memory: Verbatim traces support correct rejections (e.g., "No, I didn't see *toy*. It was *joy*."), whereas gist traces ("-oy") support false alarms. When a distractor shares orthographic gist with a target, errors can therefore be suppressed by retrieving the target's verbatim trace. The verbatim trace generates a subjective contrast effect

(known as recollection rejection; Brainerd, Reyna, Wright, & Mojardin, 2003) in which subjects notice both the similarity between the distractor and target and their nonidentity.

Here, it is possible, with the present design, to obtain purified measures of how *verbatim memory* reacts to experimental manipulations on emotion by implementing a form of signal detection analysis that was introduced by Schacter et al. (1999) and has also been used by Seamon and associates (e.g., Seamon et al., 2002). The normal method of correcting the hit rate for response bias, of which the *Pr* statistic of the earlier true memory ANOVA is an example, uses the false-alarm rate for unrelated distractors. Theoretically, false alarms to such distractors cannot be due to verbatim memory for their presentation (because they were not presented) or to gist memory for relational information (because they are not related to anything that was presented), and hence, such errors must be due to response bias. On other hand, target hits can be due to verbatim memory or gist memory or response bias, and false alarms to *related* distractors can be due to either gist memory or response bias (but not verbatim memory for targets because that will suppress such errors (Brainerd et al., 1999)). Thus, as Schacter et al. (1999) pointed out, correcting the hit rate by using the false-alarm rate for *related* distractors provides additional information beyond that which is provided by using the false-alarm rate for unrelated distractor. In particular, if the related distractor false-alarm rate is used to correct the hit rate, the resulting statistic is a purified measure on the extent to which the hit rate is based on verbatim memory. (That is because verbatim memory, gist memory, and response bias all produce hits, whereas only gist memory and response bias produce false alarms of related distractors.)

Therefore, we computed a new test of target *Pr* values for the various conditions of this experiment, using the false-alarm rates for associate pairs rather than unrelated

pairs. The mean *Pr* values appear in the next-to-last column of Table 2. Using these “verbatim” *Pr* values, we computed a 3 (context valence: negative, neutral and positive) \times 3 (context arousal: low, medium and high) \times 3 (target valence: negative, neutral and positive) \times 3 (target arousal: low, medium and high) ANOVA. Again, there was a Cue Valence \times Cue Arousal \times Target Valence \times Target Arousal interaction, $F(16, 3360)=8.57$, $MSE = .28$, $p < .001$. Post-hoc analyses of this interaction produced the following five patterns with respect to emotion’s effects on verbatim memory. First, valence’s effects were different on the cue and target sides, $F(4, 840) = 13.81$, $MSE = .28$, $p < .001$. Second, arousal’s effects were different on the cue and target sides, $F(4, 840) = 9.65$, $MSE = .26$, $p < .001$. Third, valence and arousal interacted on the cue side, $F(4, 840) = 6.92$, $MSE = .28$, $p < .001$. Forth, valence and arousal interacted on the target side, $F(4, 840) = 14.19$, $MSE = .29$, $p < .001$. Fifth, valence affected verbatim memory on both the cue and target sides, but arousal’s effects were confined to the target side. The more detailed findings were these:

Relative to neutral valence, negative valence impaired verbatim memory on both sides. Specifically, negative cue decreased verbatim memory, relative to neutral and positive cue, $F(1,210) = 17.96$, $MSE = .67$, $p < .001$, $F(1,210) = 8.12$, $MSE = .90$, $p < .01$. Negative and positive target suppressed verbatim memory, relative to neutral target, $F(1,210) = 23.00$, $MSE = .02$, $p < .001$, $F(1,210) = 5.12$, $MSE = .02$, $p < .05$. Turning to arousal, high target arousal decreased verbatim memory, relative to medium arousal, $F(1,210) = 13.65$, $MSE = .16$, $p < .001$, and low arousal, $F(1,210) = 24.24$, $MSE = .20$, $p < .001$.

DISCUSSION

In this experiment, we manipulated emotional valence and arousal factorially over the cue and target sides of word pairs. The findings were consistent with the

extant research: For true memory, there was an agreement that correct recognition was better for neutral than emotional items (see Pesta et al., 2001; Huang & Yeh, 2006). For false memory, when negative valence was not presented in study lists (Experiment 1 of Pesta et al., 2001; Kensinger & Corkin, 2004; Experiment 1A of Huang & Yeh, 2006), false memory for negative lures was less frequent than that for neutral lures due to the conceptual distinctiveness effect. However, when negative valence was experienced (even only half as often as neutral valence) in study lists, false memory for negative lures reached the same frequency as that for neutral lures (Experiment 1B of Huang & Yeh, 2006). In the current study, where negative valence was experienced as frequently as neutral valence, false memory for negative lures further increased and actually surpassed that for neutral ones. Therefore, when not confounded with conceptual distinctiveness, negative emotion increased false alarm rates.

Interestingly, the finding on negative valence is prevalent in the literature of other forms of memory with vivid physical features, such as memory of pictures and videos. For instance, in a picture-word associative paradigm, Anderson and Shimamura (2005) vocally presented participants with neutral words when they were watching silent films. The films fell into four categories: negative (and high arousal; a surgical arm amputation), positive (and medium arousal; playful penguins on glaciers), arousal (and positive; a car running through the city and country streets), and control (non-emotional; a person mixing batter). Consistent with the current results, they found that (a) memory for details of the negative film was poorer than that for the control film, (b) words associated with the negative film were recalled less than those associated with other films, (c) recognition judgments on “whether a word was presented” and “with which film it was presented” were disrupted when words were studied during the negative film, but enhanced when they were studied during the arousal film, and (d) the positive film did not affect memory in all tests. Similarly,

Touryan, Halberg, & Shimamura (2003) reported poorer memory for words presented with negative pictures. In addition, Aupee (2007), using the IAPS (Lang, Bradley, & Cuthbert, 1995), also found that accuracy scores were higher for neutral than negative and positive pictures, whereas false recognition scores were lower for neutral than negative and positive pictures.

The same effect was also observed in source monitoring literature. For example, spatial and temporal source memory for negative words were found significantly below the baseline of neutral and positive words (Maddock & Frein, 2009), while false alarm rates in source monitoring were higher for negative than for neutral material (e.g., Cook, Hicks, & Marsh, 2007). The effect of negative valence may be aptly explained by the emotional withdrawal effect proposed by Davidson (1998). According to Davidson, there are two fundamental aspects of emotion: approach and withdrawal, wherein negativity “increase(s) the distance between the organism and a source of aversive stimulation.” Being withdrawn, one is reluctant to be close to the stimulus, and only able to gripe the gist of it. As a result, the verbatim representations are incomplete and one has to rely on the gist representations, which lead to an elevation in false memory.

Overall, memory was most accurate (i.e., the difference between the hit rate and the orthographic false-alarm rate was maximal) when the valence was neutral and arousal was moderate. This was counter-intuitive because the usual beliefs are that emotional stimuli are better memorized. The discrepancy between subjective and object estimates of memories for emotional stimuli is related to a vividness feeling triggered by the emotion (Reisberg & Heuer, 2004). As a matter of fact, when emotion is involved, memory functions differently. As Comblain and colleagues (2004) demonstrated, “remember” judgments (in the Remember/Know paradigm) for emotional pictures were essentially based on the remembrance of emotional reactions

and thoughts associated with the pictures, but to a much less degree on the recollection of perceptual details. In the same vein, the fMRI findings obtained by Sharot and collaborators (2004) indicated that “remember” judgments for emotional pictures were sustained by amygdala, known to be involved in emotional arousal perception. In contrast, “remember” judgments to neutral pictures were accompanied by increased neuronal activity in the parahippocampal cortex, a region typically involved in the remembering of scenic details. In one word, emotion boosts confidence, which does not necessarily reflect the real memory accuracy.

We will further discuss dual processes and context vs. content manipulation. In connection with the verbatim *Pr* results, we found context and content emotion influenced memory via different processes. According to the fuzzy-trace theory, when verbatim processes are impaired *and* gist processes are enhanced, true memory decreases but false memory increases, which was the effects of negative context in this study. When *only* gist processes are enhanced, both true and false memories increase, which was the case of context arousal here. When *only* verbatim processes are impaired, true memory decreases without changes in false memory, which was displayed by negative content. Lastly, when *both* verbatim and gist processes are impaired, true and false memory decrease, as the effects of high content arousal.

With respect to the context-content manipulation, the data indicated that memory was influenced not only by the emotion of the *targets* but also by the emotion of the *cues*. More importantly, they had different effects. Arousal, in particular, was sensitive to the cue-target manipulation. It displayed U-shaped effects on the cue side but not on the target side. What’s more, the direction of arousal’s effects was reversed: High arousal increased both true and false memory on the cue side but decreased both memories on the target side. Thus, the context-content manipulation is especially important for studying arousal’s effects.

To conclude, it is worth noting that the emotion's effects on orthographic false memory reported in this study were consistent with those on semantic false memory from other recent studies. Negative valence, disregarding interactions, reduced accuracy of memory by narrowing the gap between the hit rate and the false-alarm rate for associate pairs¹. This net effect is the same as the net effect of negative valence in semantic false memory experiments (Brainerd et al., 2008; Howe, 2007). Concerning the size of valence effects, although negative valence affected false-alarm rates, relative to neutral valence, positive valence did not. Again, this is consistent the smaller effects that have been observed for positive valence in semantic false memory (Brainerd et al., 2008). Further, the verbatim analyses indicated that negative valence was associated with impaired verbatim memory, compared with the neutral baseline, which was also found in semantic false memory research (Brainerd et al., 2008).

The consistency is of theoretical importance because orthographic and semantic memories are two distinct cognitive processes. Orthographic false memory is memory errors for perceptually (visually) similar stimuli, whereas semantic false memory is errors for conceptually similar stimuli. We know from developmental studies (e.g., Dewhurst & Robinson, 2004; Holiday & Weekes, 2006) that false memories for semantic and perceptual relatedness showed opposite developmental trajectories from early childhood to adolescents. Semantic false memory increased with age, whereas perceptual (phonological/orthographic) false memory decreased with age. Thus it is intriguing to see that these two types of false memory respond to emotion in the same way. A theoretical interpretation would be this. As we know from the fuzzy-trace theory that false memory is based on gist representations: gist of similarity. Indeed, this is what both types of false memories have in common. The orthographic similarity (i.e., a certain visual pattern) contributes to orthographic false memory, while the semantic similarity (i.e., the same theme or category) leads to semantic false

memory. The converging findings between the two types of false memory highlighted the importance of gist as *the* underlying process of false memory.

Research on emotion and orthographic false memory is important in the fields where memory of details is crucial and memory is emotionally charged. For instance, similarity in the spelling between drug names (e.g., Xenical1 and Xeloda1) leads to not only wrong purchase of patients but also errors in prescription, dispensation, and administration of health professionals (Davis, 1997). In fact, one forth of medication errors voluntarily reported in the US identifies name confusion of drug products as the primary cause (US Pharmacopeia, 1993, 1995, 1997; Davis, 1997). Another field of implication is the law, where memory failures for perceptual details of an event can bias testimony and lead to misjudgment. Therefore, understanding how true and false memories change under emotional situations is of importance. The current study demonstrated that memory is reconstructive and manipulation of valence and arousal increased the likelihood of flawed reconstruction.

Footnotes

1. Negative valence on the cue side increased the orthographic false-alarm rates, relative to neutral or positive valence. The same numerical trend was obtained on the target side, although statistically insignificant.

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CHAPTER 4

How Do Valence and Arousal Affect Suggestibility?

Abstract

Do emotional valence and arousal increase suggestibility to false suggestive questions? Do emotional valence and arousal of memory targets have different effects than those of retrieval contexts? I investigated those questions by manipulating valence and arousal factorially in an associative recognition paradigm. Negative valence increased suggestibility for false suggestive questions, relative to positive valence, when arousal was low; no differences when arousal was high. Such effects were observed no matter emotion was manipulated over the target or the cue side, although the underlying memory processes may be different.

How Do Valence and Arousal Affect Suggestibility?

Introduction

Suggestibility, according to its broadest definition, concerns “the degree to which individuals’ encoding, storage, retrieval, and reporting of events can be influenced by a range of social and psychological factors” (Bruck & Ceci, 1999; Ceci & Bruck, 1993). It implies that (a) suggestibility is a multifaceted construct with cognitive and social bases; (b) it can be unconscious or conscious; and (c) it can result from the provision of post- or pre-event information. A narrower definition refers suggestibility to “the extent to which individuals come to accept and subsequently incorporate post-event information into their memory recollections” (Gudjonsson, 1986, p. 195; see also Powers, Andriks, & Loftus, 1979), which only focuses on the emotional-cognitive aspect (i.e., not social or inter-personal aspect), the unconscious form (i.e., not confabulation, acquiescence to social demands, or lying), and post-event information.

To measure suggestibility, Gudjonsson (1984) developed the Gudjonsson Suggestibility Scales (GSS1 and GSS2), which identified two aspects of interrogative suggestibility: “Yield”, the tendency to submit to misleading questions, and “Shift”, the tendency to change answers under conditions of social pressure. In the procedure, subjects listen to a narrative, and then report all they recall about the story. The passage is sufficiently long for them to be unable to remember all the details. Following this, the subjects are asked 20 questions about the story, 15 of which contain suggestive cues. Affirmative answers to the suggestive cues are labeled as “Yield”. After all the 20 questions are answered, the subjects are told in an authoritative manner that they have made a number of errors and must answer the questions once more and try to be more accurate this time. The 20 questions are subsequently repeated and the quantity of changes in response to the 15 suggestive

questions is scored for “Shift”.

Although emotion is widely regarded as a bi-dimensional construct with one dimension of valence and another of arousal, the majority of previous research on emotion and suggestibility either studied valence effects without controlling arousal or studied arousal effects without controlling valence. As a consequence, the findings were mixed. Concerning valence, research disagreed on whether negative valence increased or decreased suggestibility. On one hand, Ceci, Loftus, Leichtman, and Bruck (1994) reported that fewer preschool-aged children assented to a negative false event (“falling off a tricycle and getting stitches in the leg”) than a false positive event (“taking a hot air balloon ride”) (for a review, see Bruck & Ceci, 1997). On the other hand, Otgaar, Candel, and Merckelbach (2008) found that 7-year-olds assented to a negative false narrative (“being accused by the teacher for copying off your neighbor”) and developed more false memories than they did for a neutral narrative (“moving to another classroom”). There were also studies that found no relationship between valence and suggestibility. As Hyman, Husband, and Billings (1995) reported, college students assented to and created false memories for a negative childhood experience (“an overnight hospitalization”) as equally likely as for a positive one (“a birthday party with pizza and a clown”) in response to misleading information and repeated interviews.

Turning arousal, unlike valence which was manipulated in memory material, arousal was mainly manipulated as stress levels of individuals. The findings are also indecisive though. Some studies showed that arousal was associated with enhanced memory and decreased suggestibility. For example, Goodman and colleagues observed children in medical procedures and found that those who displayed higher as opposed to lower emotional arousal during medical procedures exhibited enhanced memory or no memory decrement for the procedures and less suggestibility

(Goodman, Bottoms, Schwartz-Kenney, & Rudy, 1991; Goodman, Hirschman, Hepps, & Rudy, 1991). Other studies, however, yielded the opposite result. For instance, Peters (1991) varied children's level of stress by unexpectedly sounding either a fire alarm (high stress) or a loud radio (low stress). The children were then engaged in several activities with a confederate. A week later, the high-stress group recalled less about the event and was more susceptible to misleading questions about what the confederate did, said, and looked like than did the low-stress group. Merritt, Ornstein, & Spicker (1994) also found that high arousal impaired memory for a stressful medical procedure and increased suggestibility. The discrepancy has been well documented by Bruck and Melnyk's review (2004) of 15 studies on the effects of children's arousal during the target event on their later suggestibility: 50% of the studies showed no reliable effects of stress on suggestibility, 25% showed a high stress-high suggestibility relationship, whereas 25% showed the reverse effect.

As we have seen, the method of manipulating valence (emotion of target events) is dramatically different than the method of manipulating arousal (mood states of participants). Obviously, it is important to progress to designs in which (a) valence and arousal manipulations are comparable (e.g., both manipulated on memory material), and (b) they do not confound. Recently, Porter and colleagues conducted a series of experiments on accuracy and suggestibility where they compared different valence conditions with arousal controlled. Porter, Spencer, and Birt (2003) divided subjects into three valence conditions, viewing positive, neutral, or negative scenes. Half of the subjects in each condition answered a questionnaire, with half of the questions containing misinformation. Then all the subjects took a free recall test and answered a series of open-ended questions. The researchers found the misled subjects (42.6%) were as half accurate as the nonmisled subjects (79.5%). More interestingly, emotion had a strong impact on suggestibility to the misinformation. Subjects who

saw negative scenes (80%) were twice as likely to recall seeing a suggested item in the scenes as those who saw positive or neutral scenes (40%). Later, Porter and colleagues (2010) used a slightly different design but reached to the same conclusions.

Participants viewed highly positive and highly negative pictures. Half of the participants were exposed to misinformation about the pictures and asked to answer questions concerning the details of the pictures. Their memories were tested with an interval of one week or one month. Not surprisingly, the misled participants showed less accurate memories than the nonmisled counterpart at both follow-ups. More importantly, the misled participants displayed greater suggestibility for the negative than positive pictures.

Although Porter and colleagues' studies did not confound valence and arousal, they only studied valence with arousal being equated, but did not manipulate arousal with valence being controlled. Thus it was unable to answer questions like "Do valence and arousal interact?" and "What are their respective effects?". The current study was designed in response to these interests. To do so, I manipulated two levels of valence (negative and positive) and two levels of arousal (low and high) in a factorial way.

In addition, this study had another important manipulation which has not been studied in the literature. Information processing takes place in association, that is, target information is often encoded with peripheral information. For instance, neutral events can occur in emotional contexts and emotional events can occur in contexts that are otherwise neutral. Therefore research on emotion and suggestibility should not only examine the effects of target emotion but also contextual emotion in a parallel design. In order to do so, a revised associative recognition paradigm was adopted. Valence and arousal were manipulated over *either* the context side (i.e., a non-emotional target with an emotional cue) *or* the content side (i.e., an emotional

target with a non-emotional cue).

With regard to suggestibility, this study took the narrow definition and focused on “Yields”, measured by the behavior of assenting to false suggestive questions. In sum, the present study aimed to study (a) the effects of context valence (when context arousal was controlled) and those of context arousal (when context valence was controlled) on suggestibility, and (b) the effects of content valence (with content arousal being controlled) and those of content arousal (with content valence being controlled) on the content side, which further enabled (c) a comparison of emotion’s effects on two sides.

Method

Subjects

103 undergraduates at a university in the United States participated in exchange for course credit (mean age=19 years, 58% females).

Material

The International Affective Picture System (IAPS; Lang, Bradley & Cuthbert, 1998) was used for emotional manipulation. In line with the bi-dimensional approach to emotion (Russell, 2003; Russell & Mehrabian, 1977), each picture in the IAPS was rated on 9-point scales of Self-Assessment Manikin (Lang, 1980) for valence and arousal. The valence scale ranges from positive (corresponding with the numeric value 9) to negative (numeric value 1); and the arousal scale ranges from high (corresponding with the numeric value 9) to low (numeric value 1). These photos have been shown to elicit not only subjective and expressive changes, but also physiological changes involved in emotion, such as increases in heart rate, skin conductance, and muscle activity (Lang, Greenwald, Bradley, & Hamm, 1993). Based on the normative

ratings of valence and arousal that are provided in the IAPS, I selected 16 non-emotional pictures and 16 emotional pictures. The non-emotional pictures were neutral valence and low arousal (e.g., a neutral face, mushrooms). The emotional pictures fell in one out of four conditions: negative valence and high arousal (e.g., an attacking snake, a burned face), negative valence and low arousal (e.g., a depressed girl, an ill elderly), positive valence and high arousal (e.g., an athlete winning gold medal; innumerable money), and positive valence and low arousal (e.g., a mom cuddling her baby; a butterfly on a flower), with four replicates in each condition. The mean valence and arousal values of the pictures are reported on Table 4.1.

Table 4.1. Means and standard deviations of valence and arousal of pictures

Emotion	Valence		Arousal	
	Mean	SD	Mean	SD
Negative Low	3.39	.48	3.57	.75
Negative High	2.90	1.09	6.90	.41
Positive Low	7.18	.11	3.43	.13
Positive High	7.55	.22	6.91	.40
Non-emotional	5.32	.17	3.34	.33

The selected pictures were randomly assigned and counterbalanced between cues and targets. On the study list, eight picture pairs were emotional cues and non-emotional targets, with two replicates in a 2 (cue valence: negative, positive) \times 2 (cue arousal: low, high) matrix. The other eight picture pairs were non-emotional cues and emotional targets, with two replicates in a 2 (target valence: negative, positive) \times 2 (target arousal: low, high) matrix. Six buffer picture pairs, selected from unused items in the IAPS, were presented at the beginning and end of each study list to reduce primacy and recency effects. The test list was composed of the old cue pictures and suggestive questions about the old target pictures. For each old cue-target pair in study, three cue-question pairs were presented for test: One had true statements about the old target pictures (e.g., “There was bumper-to-bumper traffic, wasn’t there?”; “The old man was eating a pear, wasn’t he?”), and two had false statements (e.g., “The plan was a passenger plan, wasn’t it?” when actually the plan was a fight plan; “Two riders in the roller coaster were wearing glasses, weren’t they” when actually only one rider was wearing glasses).

Procedure

Subjects studied a list of cue-target picture pairs and responded to a suggestibility test. The order of picture pairs on the study and test lists was randomized. In the study phase, subjects were instructed that they would see a list of picture pairs and their memories would be tested later. They were presented with one set of emotional target pictures in association with non-emotional cue pictures and another set of non-emotional target pictures in association with emotional cue pictures. Each picture pair was presented for 2.5 seconds with a 0.5 second interval. After the learning session came a filler activity. They were asked to solve a list of mathematical questions as quickly and accurately as they could.

On the suggestibility test, participants were presented with a list of

picture-question pairs. They were informed that the left picture in each pair was always the old one that they had seen on the left in the learning session, while the question on the right might or might not convey accurate information about the old picture that had previously been paired with the left picture. They were asked to respond to the questions on a 4-point scale (“A”= very confidently agree, “B”=less confidently agree, “C”= less confidently disagree, and “D”= very confidently disagree). 15 seconds were allowed to for each question.

Results

Suggestibility

The proportions of assenting to false suggestive questions (the “A” and “B” responses) were calculated for the four emotional conditions on context and content sides, respectively (see Table 4.2). On the context side, an analysis of variance (ANOVA) was conducted on the proportions of “agree” responses as a function of context valence (negative vs. positive) and context arousal (low vs. high). There was a significant valence effect, $F(1,102) = 8.19$, $MSE = .05$, $p < .01$, indicating greater suggestibility in a negative context than in a positive one. However, the Valence \times Arousal interaction was also significant, $F(1,102) = 22.29$, $MSE = .05$, $p < .001$. The post hoc analysis revealed that negative contexts increased suggestibility, relative to positive contexts, when the context arousal was low ($t(204) = 5.39$, $p < .001$). When the context arousal was high, however, there was difference between negative and positive valences.

Table 4.2. Suggestibility, confidence, and true memory as functions of emotion on context and content sides, respectively

	Suggestibility	Confidence	True Memory
Context			
N-L	.39(.24)	.07(.14)	.75(.32)
N-H	.33(.25)	.04(.10)	.52(.31)
P-L	.23(.20)	.08(.10)	.51(.34)
P-H	.37(.25)	.11(.18)	.55(.35)
Content			
N-L	.37(.26)	.09(.15)	.43(.37)
N-H	.33(.27)	.04(.11)	.43(.32)
P-L	.21(.22)	.05(.12)	.44(.37)
P-H	.31(.25)	.11(.15)	.55(.36)

Note: N-Negative valence, P-Positive valence, L-low arousal, H-High arousal.

Turning to the context side, a parallel ANOVA was conducted on the proportions of “agree” responses as a function of content valence (negative vs. positive) and content arousal (low vs. high). Again, there was a significant valence effect, $F(1,102) = 14.84$, $MSE = .06$, $p < .001$, and a significant Valence \times Arousal interaction, $F(1,102) = 10.80$, $MSE = .05$, $p < .001$. The participants yielded to misleading questions more frequently for negative targets than positive ones, when the content arousal was low ($t(204) = 5.36$, $p < .001$). No difference between negative and positive valences when the arousal was high.

Confidence Ratings

I further examined the confidence levels of the participants when they yielded to false suggestive questions: Did certain emotion make them more confident? The proportions of the high confidence rating (“A” = very confidently agree; see also, Moritz & Steffen, 2002) as a function of context valence (negative vs. positive) and context arousal (low vs. high) were calculated. Valence had significant effect, $F(1,102) = 8.21$, $MSE = .02$, $p < .01$. The high confidence rating was given more often in a positive context than in a negative context. In addition, the Valence \times Arousal interaction was also significant, $F(1,102) = 5.11$, $MSE = .02$, $p < .05$. That is, when the cue picture was at high level of arousal, positive valence increased confidence than negative valence ($t(204) = 3.58$, $p < .001$); whereas when the cue picture was at low level of arousal, confidence levels did not vary with valence.

A similar ANOVA was conducted on the proportions of the high confidence rating as a function of content valence (negative vs. positive) and content arousal (low vs. high). The main effects of valence and arousal were not significant, but the Valence \times Arousal interaction was ($F(1,102) = 23.76$, $MSE = .01$, $p < .001$). When the target picture was at high level of arousal, positive valence increased confidence than negative valence ($t(204) = 3.88$, $p < .001$); whereas when the target picture was at low

level of arousal, negative valence increased confidence than positive valence ($t(204) = 2.38, p < .05$).

Discussion

In this study, I manipulated valence and arousal factorially over context and content sides. The findings indicated that both the emotional characteristics of the target images and those of the contextual images had important impacts on suggestibility. That is, negative valence increased suggestibility when arousal was low, but not so when arousal was high. This valence-by-arousal interaction was observed on both the context and content sides.

However, different processes may underlie the effect. To explore this, two sets of analysis were conducted. First, I compared the proportions of “agree” responses to false suggestive questions and those to true questions. Considering emotion on the context side, the subjects made more “Yield” responses to both false and true information in the negative, low-arousal context than in any other emotional contexts, indicating that the negative, low-arousal context promoted individuals’ tendency of compliance, regardless of the truthfulness of the statements. Turning to emotion on the content side, however, the negative, low-arousal content had the highest proportions of assenting to false suggestive questions but the lowest proportions of assenting to true questions. It suggested that the effect of the negative, low-arousal content was related more likely to inhibited memory than an elevated tendency of compliance.

This interpretation was further supported by the second set of analyses on confidence ratings. It is interesting that although the negative, low-arousal context heightened suggestibility, it did not make the subjects more confident with their “Yield” choice. That is, although they were not very confident to give in to false suggestions, they did so anyway. In contrast, the negative, low-arousal content promoted both suggestibility and confidence, suggesting that memory was likely

impaired. Thus, the results suggested that the increased suggestibility for negative, low arousal content was associated with memory impairment, whereas the increased suggestibility in a negative, low arousal context was related to compliance.

As a matter of fact, the dissociative patterns between content and context are supported by previous studies. With respect to the target side, the literature has compellingly revealed that suggestibility is negatively related to memory (Liebman, McKinley-Pace, Leonard, Sheesley, Gallant, Renkey, & Lehman, 2002) and source monitoring (Johnson, Hashtroudi, & Lindsay, 1993). Furthermore, memory and source monitoring are more likely to be impaired for negative valence (e.g., Brainerd, Stein, Silveira, Rohenkohl, & Reyna, 2008; Maratos, Allen, & Rugg, 2000; Maddock & Frein, 2009; El Sharkawy, Groth, Vetter, Beraldi, & Fast, 2008). It is primarily because false memory relies heavily on interconnected associative structures (Brainerd & Reyna, 2005; Gallo, 2006), and negative emotional information is indeed more semantically dense and highly interrelated in memory (Talmi, Luk, McGarry, & Moscovitch, 2007; Talmi & Moscovitsch, 2004). That is, negative content is associated with impaired memory, which in turn is related to increased suggestibility; therefore, it was not surprising to observe higher suggestibility for negative content.

Turning to the context side, it is intriguing that, although context in this study referred to contextual stimulus, which is very different from moods (mental context), the findings in this study are consistent with those in mood manipulation studies. For example, some previous research (e.g., Goodman, Quas, Batterman-Faunce, Riddlesberger, & Kuhn, 1994; Levine, Burgess, & Laney, 2008) examined discrete emotions such as sadness (negative, low-arousal) and happiness (positive, high-arousal). Their results compellingly demonstrated that sadness influenced one to be particularly vulnerable to suggestion, relative to other emotions. Such effect is consistent with appraisal theory that discrete emotions lead to different cognitive and

interpersonal problem-solving strategies (e.g., Frijda, 1987; Keltner & Gross, 1999; Scherer, 2003; Smith & Lazarus, 1993): Happiness is associated with goal attainment, which signals that no diversion of cognitive resources is necessary (Schwarz & Clore, 1983) and evokes feelings of self-efficacy (Izard & Ackerman, 2000).

Correspondingly, memory retrieval is facilitated (for a review, see Isen, 2000) and individuals are less likely to give in to misleading information (Ceci & Bruck, 1993). In contrast, sadness is associated with a sense of irrevocable failure, the belief that one's own resources are inadequate, and thus the tendency of seeking help and comfort from others (Izard & Ackerman, 2000). Thus, sadness leads to feelings of low self-efficacy and increased reliance on others for help with a predicament (Saarni, 1997).

The current study has implications for the law, where memory reports are the most important form of evidence (Brainerd & Reyna, 2005; Ceci & Friedman, 2000). Crimes are highly emotionally charged events. Through interviews and testimony, requested memories can be information which itself is emotional or which is cued by other emotional information, and the retrieval process is often contaminated by suggestive questioning and misinformation. Therefore, the question of how suggestibility is affected by emotional content as well as by emotional context is of special interest.

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CHAPTER 5

Was the Good That Good?

—— Positive Bias of Past Performance

Abstract

Previous research has indicated that false memory in general is related to gist process, whereas memory distortions of autobiographical events are related to the self system. Taken together, the current experiment examined positive bias of past performance as a function of gist (i.e., whether the performance was positively evaluated) and the self (i.e., whether the performance was perceived irrelevant to, consistent with, or inconsistent with one's current active goal). Students participated in an academic test; three weeks later, they took a surprise memory test on their memories for the previous performance. They exhibited a general tendency to reconstruct false positive details, through recalling being correct on more test items than they actually did. This positive bias was especially strong when the test result was positively evaluated or when good performance was consistent with goal achievement. Gist was influential in the situation where the test was irrelevant to the self; in situations where the performance was relevant (including consistent and inconsistent), however, positive bias varied primarily with perceived impacts of the past performance on the self: positive bias was strong in the consistent condition (regardless of evaluation), but restricted in the inconsistent condition (especially in the presence of positive evaluation).

Was the good that good?

—— Positive bias of past performance

Since the pioneering work of Bartlett (1932), research has compellingly revealed the inherently reconstructive nature of episodic memory and its proneness to distortions (e.g., Garry & Wade, 2005; Reyna, 2000). False memory for impersonal stimuli is conceptualized from a dual-processes perspective — a gist-like conceptual process and a verbatim-level perceptual process, and thus understanding false memory to be the combat between these two processes (e.g., Brainerd & Reyna, 2002, 2005). Theories on autobiographical events (e.g., Conway & Pleydell-Pearce, 2000; Conway, 2005), on the other hand, maintain a self-memory bidirectional model, argue that memories provide context for the self and the self system exercises control over memories, and ascribe memory distortions to self-serving motives (e.g., Ross & Buehler, 2001). In the current study, we are interested in how the cognitive effect of gist and the motivational effect of self work together on positive bias in autobiographical memory: Do individuals reconstruct false positive memory details of their past performance? Does it depend on whether the performance has been evaluated as “good”, or how important the past performance means to the current self, or both? Some background on the effects of gist and self on false memory, respectively, is provided before reporting our research.

Gist and False Memory

Gist is an important concept (fuzzy-trace theory; Brainerd & Reyna, 2002, 2005) in understanding memory falsification in general. According to the theory, humans have two kinds of memory representations: verbatim representations that record surface-level sensory details, and gist representations that represent general interpretations, meanings, patterns and relations. Retrieval of verbatim traces is a vivid form of remembering in which one consciously re-experiences previous events and

specific contexts. It protects memory from distortions. By contrast, retrieval of gist traces is a more generic form of remembering, which allows inaccurate information to slip in recollection. Importantly, verbatim traces are susceptible to interference and fade out quickly over time, whereas gist traces are robust and enduring. As the accessibility of verbatim traces is reduced, gist traces dominate consolidation, reconstruction, and recollection of memory. Correspondingly, a process known as phantom recollection occurs, where false but gist-consistent details are recalled or recognized (Brainerd, Payne, Wright, & Reyna, 2003; Brainerd, Wright, Reyna, & Mojardin, 2001).

Such gist-driven false memories have been observed in a variety of situations, including word learning (e.g., Deese, 1959; Roediger & McDermott, 1995; Underwood, 1965), sentence and story memory (e.g., Reyna & Kiernan, 1994), memory of faces (e.g., Reinitz & Hannigan, 2001), memory of eyewitness (e.g., Lindsay & Johnson, 1989), and memory for naturalistic scenes (e.g., Lampinen, Copeland, & Neuschatz, 2001). The literature converged to the finding that when a substantial amount of verbatim traces have faded, individuals fill in memory gaps based on the gist (Bergman & Roediger, 1999; Spiro, 1980).

The subtype of gist we are interested in current study is evaluation. Evaluation is a positive or negative assessment of a stimulus, which has a particularly salient affective component in addition to its cognitive component (Ferguson, 2007). Correspondingly, evaluation is processed faster than plain cognitive information (Duckworth, Bargh, Garcia, & Chaiken, 2002; Murphy & Zajonc, 1993), and exhibits a slower forgetting rate that outlasts when other memory details have already been forgotten (Koriat, Levy-Sadot, Edry, & de Marcas, 2003; Zajonc, 1980). As a result, people give significant weight to their evaluation of things, recall consistent information accurately and display evaluation-congruent distortion (Hirt, McDonald,

& Erickson, 1995). In a word, it is not surprising that we sometimes report past events in a way that diverges from historical reality in order to better match the overall evaluation of the events.

Self Goal and False Memory

As James Mill (1869) wrote, “The phenomenon of Self and that of Memory are merely two sides of the same fact, or two different modes of viewing the same fact. ... This succession of feelings, which I call my memory of the past, is that by which I distinguish my Self” (p. 174). The modern theory Self Memory System (SMS; Conway & Pleydell-Pearce, 2000; Conway, 2005) follows the line of the interconnectedness between memory and self. It argues that autobiographical memory is not an experience-near record of ongoing events because memory is subject to the control of the self and often biased in favor of the self. According to the SMS, self is conceived as a set of goals with associated self-images, collectively referred to as the working self. The goals are organized in a highly complex goal-sub-goal hierarchy. At a given time, some subset of the goal structure is more active than others. The purpose of the goal hierarchy is to reduce discrepancies between active goal and the current status. To achieve this, the goal hierarchy operates as a gateway, selecting what new knowledge to enter long-term memory, what preexisting knowledge to be accessed, and what memories to be constructed. Therefore, memories can be altered, distorted, even fabricated, to support the *current active* goal of the self.

In general, autobiographical memory is subject to the self’s motive to maintain and enhance the positivity of one’s self-concept (Greenwald, 1980; Sedikides & Strube, 1997), and its motive to maintain a coherent and stable self and self-world interaction that extend beyond the present moment (Conway & Pleydell-Pearce, 2000; Conway, 2005). As a consequence, individuals remember their past performance better than it was in reality (Crary, 1966), not only when they are unaware of their

objective standings (Dunning, Heath, & Suls, 2004) but also after they have been informed of the precise values of their scores (Gramzow & Willard, 2006; Willard & Gramzow, 2008). They also recall past events as having been more positive than they initially felt about the events (Christensen, Wood, & Barrett, 2003). Moreover, they preferentially recall positive events but ignore or forget negative self-relevant information (Sedikides & Green, 2000; Walker, Skowronski, & Thompson, 2003). When there is doubt about certain specifics of one's past, there is a tendency to form lofty recollections of those specifics (Greenwald, 1980).

Interestingly, although Western individuals generally overestimate the objective quality of their past performance as aforementioned, sometimes they may not. According to temporal self-appraisal theory (Ross & Wilson, 2003; Wilson & Ross, 2001), individuals would not overestimate their performance if doing so makes present achievement pale by comparison. Rather, they would recall their past in a way so that makes them feel good about their current self or fulfills their need of perceiving the self as a continuously improving agent. For instance, they may downplay a past self to make current self more appealing, through exaggerating the improvement from the past. Thus, whether one has positive bias for the past is associated with his perceived impacts of the past achievement on the current self.

The Present Study

Note memory distortions in general are associated with people's reliance on the theme or impression of the experience (e.g., gist), whereas memory distortions for autobiographical events are related with the self. Taken together, what are the relative effects of the self and gist on positive bias? This question has not been studied and is the focus of the present experiment. Here, we manipulated both gist and self goal in a factorial design. For gist, we compared a situation which provided positive evaluation after performance with another that did not provide evaluation. The effect of self-goal

was examined across a situation where the performance was irrelevant to a current active goal (irrelevant), a situation where good performance would directly reinforce goal achievement (consistent), and a situation where good performance would work against the goal achievement (inconsistent).

Our memory outcome was different than previous studies on positive bias that looked at recall of overall scores (e.g., Willard & Gramzow, 2008). We examined false positive memory *details*. This was done by asking participants to recall their answers to *individual* test items and measuring the amount of falsely recalling one had chosen correct answers when actually not. That is, we examined memory distortion at a more process level: Can memory details be distorted under the impacts of gist and self goal?

Based on the prior research, we expected that both the gist and self goal manipulation would have significant effects on reconstructing positive memory details. Pertaining to the gist effect, we hypothesized that participants receiving positive evaluation would report more false positive details than those receiving no evaluation. Pertaining to the self effect, in the absence of positive evaluation, participants in the consistent condition would report more false positive details than those in the irrelevant or inconsistent condition. We did not have specific hypothesis to the interaction effect between self and gist.

METHOD

Participants

A total of 139 undergraduate students (78% female, ages 18-24) from a University at the East Coast participated. The recruitment advertisement clearly indicated that only students who had interests in pursuing a PhD in Psychology were invited for this study. Students participated in exchange for extra course credits. Participant age and gender did not influence the results.

Material

We selected 30 GRE in Psychology Subject test items from the Princeton Review and online resources. All those test items were originally designed to test college students' comprehensive knowledge on Psychology. All test items were multiple choice formats, and students were instructed to choose one best answer from five options.

Procedure

We manipulated two levels of gist (positive evaluation vs. no evaluation) and three levels of self goal (irrelevant, consistent, or inconsistent), yielding six conditions. Participants were randomly assigned to one of the six conditions. All participants completed a test booklet with 30 test items in small groups. Depending on the assignment of self goal conditions, different versions of "the purpose of the test" were provided at the beginning part of test booklet. For students in the irrelevant self goal condition, the stated purpose of the test was phrased as irrelevant to their competency and goal pursuit: The test was one of the first trials in an attempt to develop a new pool of exam items for a testing agency. Students were thanked for their contribution. For self goal consistent and self goal inconsistent conditions, the stated purpose of the test, however, was phrased as highly relevant to their competency and goal pursuit: Some professors from a Psychology program in the Ivy League universities were organizing a special program, in which they would provide selected students with pre-graduate school trainings, research opportunities, and recommendations on behalf of the students. They were interested in students who got the highest scores on this exam. The test had been used among top colleges and universities and proved to be a very sensitive and effective measure of knowledge and potential. Students were encouraged to try their best and to become a candidate of the program. Other test instructions were otherwise the same. They were asked to select the one response that

was best in each case and then fill in the corresponding space on the answer sheet. A maximum of 30 minutes was allowed to complete the test.

All the participants were contacted three weeks later with a surprise memory test. Each received an individualized letter with his/her name on it, but the content on test purpose and performance evaluation differed among six conditions. For those in the self goal irrelevant condition, half received a positive evaluation, and the other half received no evaluation. The letter in the positive evaluation condition first reminded the students that they took a GRE Subject test to help a testing agency develop exam items, then provided grading information (“The grading criteria were poor, below average, average, above average, and outstanding.”) and the student’s grade (“What you have got is outstanding.”). The letter in the no-gist condition simply restated the purpose of the test, without the information on grading criteria or students’ grades.

In the self goal consistent condition, the letter restated that the purpose of the previous test was to select students for privileged opportunities. In the self goal inconsistent condition, however, the letter alerted the participants that “The selection will involve a second test to be scheduled in three weeks. What the examiners think highest of is the increase in scores between the tests, which indicates the competency of continuing improvement. That is, progress between the tests will be highly valued, whereas regress or no progress will be considered disadvantageous.” In the following paragraph of the letter, students in both conditions received either positive feedback or no feedback.

After reading the letter, all the participants were given a surprise memory test. They were provided with a copy of the original test they took three weeks ago. However, the answer key to each question was included. They were asked to recall carefully which answer they previously selected for each of the questions. The participants were debriefed after their participation.

RESULTS

For each participant, we graded his/her original response to each test item in the first session, and compared them to his/her retrieval in the second session. There were five potential relations between the retrieval and the original responses (see Table 5.1). Three were false memories: (a) one chose an incorrect answer on the test but recalled s/he had chosen a correct one (*over-report*); (b) one chose a correct answer on the test but recalled s/he had chosen an incorrect one (*under-report*); and (c) one chose an incorrect answer in the test but recalled s/he had chosen another incorrect one (*neutral-change*). Among them, the *over-report* measured the extent of constructing unrealistically positive memories and thus was the focus of our analysis.

Table 5.1. Relations between the actual responses and the retrievals

Relation	Response in session 1	Retrieval in the session 2
Correct retrieval	Correct	Correct
Correct retrieval	Incorrect	Same incorrect
Over-report	Incorrect	Correct
Under-report	Correct	Incorrect
Neutral change	Incorrect	Different incorrect

In general, as many as 99.4% of the participants made at least one over-report; 82.3% of the participants made at least one neutral change; and only 74.1% of the participants made at least one under-report. We conducted a 3 self-goal (irrelevant, consistent, inconsistent) \times 2 gist (positive, no) between-subjects analysis of covariance (ANCOVA) on over-report. Three variables were included as covariates to remove confounding effects (Wilkinson, Hill, & Vang, 1992): To account for individual differences in memory failure, we included the counts of neutral-change and under-report as covariates. In addition, the total of correct answers in the first session (total-correct) was also a covariate because it was related to over-report (for instance, one who got full points in the first session would have no possibility for over-report). Because the memory variables were count data and positively skewed (except total-correct was normally distributed), they were submitted to square root transformations. The square-rooted neutral-change and square-rooted total-correct were significant covariates, but not the square-rooted under-report. Thus the ANOVA rerun with the square-rooted under-report excluded (SYSTAT, 1992). All F values reported below have the effects of the covariates controlled.

The main effect of self goal was significant, $F(2, 131) = 6.90$, $MSE = .42$, $p < .001$. Participants who regarded the test consistent with their goal pursuit modified performance on more items from incorrect to correct ($M = 2.47$, $SD = .86$) than participants who regarded good performance on the test a threat to the goal achievement ($M = 2.27$, $SD = .99$) or irrelevant to the self ($M = 2.37$, $SD = .70$) did. The main effect of gist was also significant, $F(1, 131) = 4.91$, $MSE = .42$, $p < .05$, indicating that participants who received positive feedback ($M = 2.52$, $SD = .81$) modified performance on more items from incorrect to correct than participants who received no feedback ($M = 2.26$, $SD = .85$).

The interaction was marginally significant, $F(2, 131) = 2.98$, $MSE = .42$, $p =$

.05 (see Figure 5.1). Participants in the self goal consistent condition always reported the most over-report among the three self condition groups, no matter the positive evaluation was provided or not. Then we will then use self goal consistent condition as a reference level to further illustrate the interaction effect. In the absence of positive evaluation, participants in self goal irrelevant condition reported significantly less over-report than those in self goal consistent condition, $t(40) = 3.74$, $SE = .21$, $p < .001$. When positive evaluation was provided, however, participants in the irrelevant condition reported the same amount of over-report as participants in the consistent condition, $t(43) = 1.15$, $SE = .22$. When self goal consistent and inconsistent conditions were compared, no significant difference in over-report was observed when no evaluation was provided, $t(50) = 1.54$, $SE = .19$. Interestingly, given the positive gist, over-report of the inconsistent condition significantly dropped from that of the consistent condition, $t(55) = 2.71$, $SE = .18$, $p < .01$. Positive gist did not facilitate but rather prohibited the over report when good performance was perceived as a threat to the goal achievement.

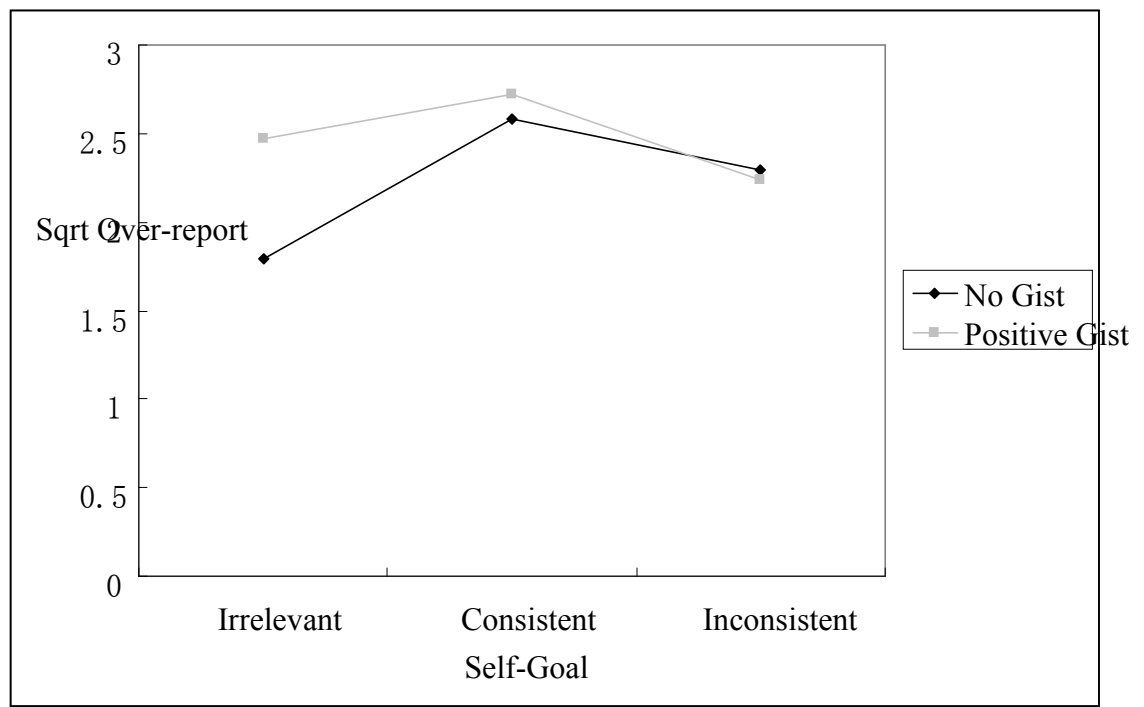


Figure 5.1. Square-rooted counts of over-report as a function of evaluative gist (no-gist, positive-gist) and self goal (irrelevant, consistent, and inconsistent)

DISCUSSIONS

We are interested in positive bias of past performance as a function of gist and self goal. The overall results are: (a) individuals tended to reconstruct false positive details in their memory of past performance; (b) the positive bias was especially boosted when the performance had been positively evaluated or (c) if the performance was meaningful for one's capacity and beneficial to the self-goal; (d) however, the positive bias was restricted if good performance was a potential threat to the goal pursuit.

The robust effect of positive evaluation indicated that the gist of how well one has performed could contaminate the verbatim memory (i.e., episodic details) of one's performance. As suggested by fuzzy-trace theory (Brainerd & Reyna, 2002, 2005), the gist representations sustain when the verbatim traces fade. The waning of verbatim traces results in memory gaps, which people have a tendency to fill in accordance with the gist. During the retrieval process, gist-consistent false details are constructed, and even information that violates the gist is distorted to be more consistent with the gist than it really had been (Cohen, 1981; Fischhoff & Beyth, 1975; Greenwald, 1980; Hirt, Erickson, & McDonald, 1993; Ross, 1989; Ross & Buehler, 1994, 2001; Schacter, 1996; Singer & Salovey, 1993; Wilson & Ross, 2001). Because biases are more pronounced for abstract traits (e.g., ability) than for concrete attributes (e.g., specific grades), the more times people recall at an abstract gist level how positive their past was, the more likely they are to make up incorrect details (Wells & Sweeny, 1986). One interesting thing to note is that the positive feedback in our experiment was arbitrarily assigned independent to the students' actual performance. However, it still had a significant effect in biasing their verbatim-level recall. This is in line with previous findings that people are sensitive to and adept at making use of external information as evidence to pursue a positive feeling for the self (e.g., Kunda, 1987;

Pyszczynski & Greenberg, 1987).

On the other hand, our results highlighted that self goal plays a substantial role in autobiographical memory reconstruction. Research in social cognition has consistently demonstrated that the self functions as a cognitive prototype that biases the processing of any personally-related information (see Kuiper & Derry, 1980, for a review). It is worth noting that although gist imposed impact on positive bias for the irrelevant condition, the impact was much limited for the consistent and inconsistent conditions. The consistent and inconsistent condition — both are highly self –relevant — responded primarily to the manipulation of self-goal. That is, to what extent one displays positive bias depends on his/her perceived relationship between the past performance and the current active goal, regardless of gist manipulation. This is supported by McDonald and Hirt's (1997) notion that although evaluative beliefs lead to the distortion of memories when one harbors no specific motivation and when one is motivated to confirm the evaluative beliefs, it is not the case when one is motivated to disconfirm them. The self ignores the external information if it is not self-serving. For example, in Gramzow and Willard's (2006), 38% of the participants receiving negative feedback ("poor") overestimated their performance anyway. These participants might be skilled at interpreting and recalling negative feedback in a self-protective manner (Brown & Dutton, 1995), or dwell on their strengths rather than weaknesses following disappointments (Steele, Spencer, & Lynch, 1993). Regardless, it suggested that autobiographical memory is shaped according to the need of the self more than in response to the gist.

In summary, memory is influenced in powerful ways by external and internal factors. Evaluation, in the current study, is an external factor. It modifies memory details to be aligned with the evaluation. On the other hand, the current active goal of the self is an internal factor. Although memory reconstruction may be beyond

awareness, it is hardly “unintentional”. On top of the influence of gist, autobiographical memory distortions are primarily driven by the self: The more relevant an event is to the self, the more likely its memory details will be reconstructed; and the more beneficial a good performance is to one’s goal pursuit, the more likely the memory details will be positively biased. In the situation where good performance works against goal achievement, however, positive bias will be restricted; and the more salient the positive evaluation is, the more restricted the positive bias will be.

Implications

There are certain things in our lives that remembering them is a joy: although the details may be foggy, our impression is distinctly positive. For many of these events, we will never have a chance to experience them again; whereas for others that we do have a chance, we somehow feel that the re-experienced are not as good as the previously experienced. Such “not that good” experiences make us wonder: Do we exaggerate the positivity in mind? As suggested by our study, we sometimes do but sometimes not.

When we do, the biased memories not only provide us with a constrained interpretation of our past, but also have behavioral consequences. Although it could be adaptive to have sweet memories of the past, it could also be maladaptive. People not only believe in their false memories, but also act on the basis of these memories (Loftus, 2003). The exaggerated sweet memories could form a distorted reference for social comparison and decision making, invoke excessive feeling of nostalgia, and impede us from enjoying the present, exploring new opportunities, and striving for a better future. By knowing that we tend to exaggerate how good the past was under the influence of self goal and the gist attached to the experience, we may want to be careful with our nostalgic feelings. Fortunately, being aware of a potential threat that a

past achievement may have on a goal pursuit and our current/future well-being appears to enable us to moderate the distortion.

Our findings yield new support for the self-enhancing bias rooted in North American culture, which however are not universal. People in the Eastern culture (e.g., the Japanese) are more self-critical (Heine, Lehman, Markus, & Kitayama, 1999), highly responsive to failure feedback (Heine, Kitayama, & Lehman, 2001), and have larger actual-ideal self-discrepancies (Heine & Lehman, 1999). Therefore, an interesting future study can look at how the self and gist processing affect positive bias in the Eastern culture.

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CHAPTER 6

General Conclusion

Now to address the questions concerning false memory and emotion, does emotion of memory targets have different effects than emotion of retrieval contexts? Yes. The context vs. content manipulation is especially important for studying arousal's effects. Furthermore, do emotional valence and arousal increase semantic false recognition, orthographical false recognition, and suggestibility? And how, at a process level, does emotion influence these false memories? The finding of overriding significance is that negative valence, when disentangled from arousal, suppresses true memory and elevates false memory, resulting in a declined net accuracy. At a more fundamental level, negative valence dilutes verbatim processes and stimulates gist processes. These findings are consistent with FTT and empirical data that (a) valence is a conceptual property, and negative valence is an especially salient gist (Brainerd, Stein, Silveira, Rohenkohl, & Reyna, 2008a), and (b) negative valence also impairs the ability to use verbatim traces of true experience to suppress distortions (Brainerd, et al., 2008).

It is worth noting that our recent study (Brainerd, Holliday, Reyna, Yang, Toglia, in press) further investigated the developmental trajectory of the effect's emotion on false memory. We administered the Cornell/Cortland Emotion Lists (CEL; Brainerd, Yang, Toglia, Reyna, & Stahl, 2008b), a word pool that induces false memory and that allows factorial manipulation of valence and arousal, to children, adolescents, and adults. Significant developmental reversals were obtained. With three age groups (7, 11, 20), false memory increased with age at a greater speed than true memory. More importantly, the negative valence effects, which were the same as those in the current study, waxed with age. These developmental trends are consistent with findings in brain development of later-maturing prefrontal regions between early childhood and adolescence (Paz-Alonso, Ghetti, Donohue, Goodman, & Bunge, 2009) as well as cognitive development of clustering and connecting individual items that

share similarities (e.g., Bjorklund & Jacobs, 1985). Considering that cognitive capacity is necessary to make links between cues and targets, it may be interesting to study whether the effects of *contextual* emotion will increase with age as well.

Another recommendation for future study on false memory and emotion is cultural difference. Western culture encourages expression of emotion, whereas Eastern culture tends to value regulating emotion and maintaining more control. Thus, negative emotion is generally repressed, which is a widely accepted cultural goal (Wang, 2003). However, the unconscious mind is more powerful in bringing out impulsive behaviors than the conscious mind. Therefore pervasiveness of emotional suppression may lead to memory effects, especially distortion effects, which are culturally distinct from those that have been observed with Western subjects.

Turning to false memory and the self, what are the effects of the self and gist processing on positive bias of autobiographical memory? Both are effective, but each dominant in different situations, depending on the perceived relations between the past event and the current active goal of the working self. The findings yield new support for the positive self-regard and self-enhancing biases rooted in North American culture, which however are not universal. People in the Eastern culture (e.g., the Japanese) are more self-critical (Heine, Lehman, Markus, & Kitayama, 1999), highly responsive to failure feedback (Heine, Kitayama, & Lehman, 2001), and have larger actual-ideal self-discrepancies (Heine & Lehman, 1999). Therefore, an interesting future study can look at how the self and gist processing affect positive bias in the Eastern culture.

One main limitation of the current studies is that we have not investigated long-term effects (over periods of days, weeks, and months); these effects of emotion are particularly important in the law, medicine, and psychotherapy because there are normally extensive delays between the time events happened and the time they are

retrieved. Another limitation is that the experimental materials we have used are emotional words and pictures, which are less complex and less self-involved than real-life events (e.g., trauma, crimes). The tradeoff here is that word and picture norms allow precise manipulations of emotional attributes. Noteworthy, research recently revealed that people's emotional reactions were similar for real-life events and words (Rubin & Talarico, 2009). Giving the robustness of the findings, the current studies provide the basic results for understanding the effects of emotion on memory, which may be applicable to real-life situations to a good extent.

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